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FEASIBILITY OF CITIZEN CONSTRUCTION OF EXPEDIENT FALLOUT SHELTER--ETC(U)

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Feasibility of Citizen Construction of Expedient Fallout Shelters

FINAL REPORT

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Interagency Agreement DOE 40-31-64
Work Order DCPA 01-76-C-0291
Work Unit 1637E

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OAK RIDGE NATIONAL LABORATORY
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ORNL-5368

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FINAL REPORT

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ADA058051



AD No. _____
DDC FILE COPY

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
Price: Printed Copy \$7.25; Microfiche \$3.00

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ORNL-5368
Dist. Category UC-41

Contract No. W-7405-eng-26

ENERGY DIVISION
Solar and Special Studies Section

SUMMARY

FEASIBILITY OF CITIZEN CONSTRUCTION OF
EXPEDIENT FALLOUT SHELTERS

Final Report

by

Spencer J. Condie, Ph.D., Sociologist
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with FOREWORD by Cresson H. Kearny
Observer for Oak Ridge National Laboratory
the Primary Contractor for
Defense Civil Preparedness Agency
Washington, D.C. 20301

Interagency Agreement DOE 40-31-64
Work Order DCPA 01-76-C-0291
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DCPA Review Notice

This report has been reviewed in the Defense Civil Preparedness Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Defense Civil Preparedness Agency.

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FEASIBILITY OF CITIZEN CONSTRUCTION
OF EXPEDIENT FALLOUT SHELTERS

Spencer J. Condie Reese J. Goodwin John F. A. Seggar

SUMMARY

Seventeen different families or groups of individuals untrained in building techniques constructed one of the following seven alternative expedient fallout shelters: Door-Covered Trench, Log-Covered Trench, Car-Over-Trench, Above-Ground Door-Covered, Crib-Walled, Ridge-Pole, and Tilt-up Doors and Earth.

The builders of each shelter were guided only by one-page instructions prepared for that shelter by Defense Civil Preparedness Agency. Nine of these same families or groups also built an expedient shelter-ventilating pump, following brief instructions of Defense Civil Preparedness Agency.

To simulate crisis conditions, the groups were offered a base pay rate for constructing each respective shelter within a specified time frame. If the shelter were completed in half the specified time, an additional bonus was given. With the exception of only one group, all participants received the bonus.

Generally speaking, the participants demonstrated that construction of the respective shelters in accordance with the shelter designs was feasible. The builders were less successful in following the brief instructions for making an expedient air pump. Of the nine pumps built, only four would pump air effectively.

Numerous suggestions were made by the participants and observers regarding the improvement of the instructions. Among the more general suggestions were: (1) instructions should not be condensed to only one page; (2) brief explanations should be given regarding why certain steps are taken; (3) selection criteria for locating a shelter site should be suggested; (4) more illustrations which are less complex should be included in each set of plans.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ORNL-5368	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) FEASIBILITY OF CITIZEN CONSTRUCTION OF EXPEDIENT FALLOUT SHELTERS.		5. TYPE OF REPORT & PERIOD COVERED Final Report.
6. AUTHOR(s) Spencer J./Condie Reese J./Goodwin John F. A./Seggar		7. PERFORMING ORG. REPORT NUMBER W-7445-eng-26
8. PERFORMING ORGANIZATION NAME AND ADDRESS Oak Ridge National Laboratory P.O. Box X Oak Ridge, TN 37830		9. CONTRACT OR GRANT NUMBER(s) Interagency Agreement DOE-40-31-64 DCPA 01-76-C-0291
10. CONTROLLING OFFICE NAME AND ADDRESS Defense Civil Preparedness Agency Washington, D.C. 20301		11. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Work Unit 1637E
12. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 121p.		13. REPORT DATE August 1978
		14. NUMBER OF PAGES 118
		15. SECURITY CLASS. (of this report) Unclassified
		16. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of this Report) APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED		
18. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
19. SUPPLEMENTARY NOTES		
20. KEY WORDS (Continue on reverse side if necessary and identify by block number) expedient fallout shelters shelter-building instructions shelter-ventilating pump		
21. ABSTRACT (Continue on reverse side if necessary and identify by block number) Seventeen families attempted to build seven types of earth- covered expedient fallout shelters while guided only by one-page shelter-building instructions prepared by DCPA. Within 48 hours of starting, all but one family succeeded in building a shelter affording good fallout protection. Families spent an average of 88 minutes trying to interpret their one page of instructions.		

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

20. ABSTRACT (continued)

The abbreviated DCPA instructions for building an expedient shelter-ventilating pump — essential for the multiday occupancy of below-ground shelters, except in cold weather — were followed successfully by only four out of nine families. This report makes numerous recommendations for improving all the instructions.

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SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

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Brigham Young University, Provo, Utah

Foreword by

Cresson H. Kearny
Oak Ridge National Laboratory

Interagency Agreement DOE 40-3164
Work Order DCPA 01-76-C-0291, Work Unit 1637E

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CONTENTS

	<u>Page</u>
LIST OF FIGURES	v
LIST OF TABLES	ix
FOREWORD	xi
ABSTRACT	1
1. INTRODUCTION	3
2. DEMOGRAPHIC CHARACTERISTICS OF SHELTER CONSTRUCTION PARTICIPANTS	6
3. LOCATION OF CONSTRUCTION SITE	9
4. FINDINGS	10
4.1 Door-Covered Trench Shelter	10
Suggestions for Improvements	13
4.2 Log-Covered Trench Shelter	16
Suggestions for Improvements	33
4.3 Car-Over-Trench Shelter	34
Suggestions for Improvements	38
4.4 Aboveground Door-Covered Shelter	38
Suggestions for Improvements	45
4.5 Crib-Walled Shelter	46
Suggestions for Improvements	53
4.6 Ridge-Pole Shelter	54
Suggestions for Improvements	62
4.7 Tilt-up Doors and Earth Shelter	62
Suggestions for Improvements	67
4.8 Construction of Air Pumps	67
Suggestions for Improvements of Air-Pump Instructions	76
Appendix A - BASE PAY RATE AND BONUSES FOR CONSTRUCTION OF EACH SHELTER DESIGN	79
Appendix B - AGREEMENT	81
Appendix C - SUGGESTED REVISION OF LAYOUT FOR DOOR-COVERED TRENCH SHELTER	83

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
F.1	Field-tested instructions for making a shelter-entry canopy	xiii
4.1	Canopies neatly erected over Door-Covered Trench Shelter entrances	14
4.2	Two young, single women digging the trench for a Log-Covered Trench Shelter	20
4.3	Interior of Log-Covered Trench Shelter	21
4.4	Young women covering logs with newspapers prior to shoveling dirt into log-covered trench	22
4.5	Completed 4-person Log-Covered Trench Shelter	22
4.6	The second Log-Covered Trench Shelter was constructed by a young family with six children under the age of 10	23
4.7	All but the two youngest children assisted in the very effective division of labor involved in constructing this shelter	24
4.8	The father interpreted the trench instructions as requiring 2 ft 9 in. per person rather than per adult	25
4.9	In addition to assisting in the trench excavation, the young children also aided greatly in carrying logs to the trench	26
4.10	Dragging the logs with an expedient yoke was somewhat easier for the children than carrying the heavy logs	27
4.11	The children are fastening the yoke cord to the long pole prior to dragging it to the trench site	28
4.12	Covering the trench with quaking aspen logs	29
4.13	Filling sandbags was yet another contribution of the children which allowed their parents time to consult instructions and to perform the heavier and more exacting labor	30
4.14	Covering the trench	31
4.15	The six children admire the nearly completed shelter	32
4.16	Successfully completed Car-Over-Trench Shelter	37

<u>Figure</u>		<u>Page</u>
4.17	Rear left wheel of car driven too close to side of trench	37
4.18	Interior doors used for forms, preparatory to using bed-sheet fabric to make earth-roll walls	41
4.19	Roofing on partly completed Aboveground Door-Covered Shelter	42
4.20	Nearly completed entrance of an Aboveground Door-Covered Shelter	43
4.21	Completed Aboveground Door-Covered Trench Shelter	44
4.22	This family, who constructed a Crib-Walled Shelter, discovered that in order to fill the cribs and cover the roof, this aboveground shelter required more digging than many trench-type shelters	50
4.23	Crib walls which have been lined and are ready to be filled	50
4.24	Exterior crib walls	51
4.25	Crib-Walled Shelter prepared for earth-covered roofing	51
4.26	A nearly completed Crib-Walled Shelter	52
4.27	Making the frame of a Ridge-Pole Shelter	57
4.28	Side view of a ridge-pole frame	58
4.29	Sticks placed horizontally	58
4.30	Ridge-Pole Shelter nearing completion	59
4.31	One of the two right-angle entryways of Ridge-Pole Shelter, before being covered with earth	59
4.32	Interior view of Ridge-Pole Shelter	60
4.33	Putting the finishing touches on a Ridge-Pole Shelter	61
4.34	End view of Tilt-up Door and Earth Shelter	66
4.35	Closed end of a smaller Tilt-up Doors and Earth Shelter, built by two young women, indicating a weakness in the instructions	66
4.36	Upper left -- Note the crooked pivot wires, which prevented flaps from swinging freely	72

<u>Figure</u>		<u>Page</u>
4.37	Although this pump was constructed in accordance with the design instructions, the pivot wire was secured directly against the wire mesh used as a flap stop	73
4.38	The group who constructed this pump interpreted the use of "tacks" in the instructions as referring to thumbtacks	74
4.39	This is a properly constructed air pump which conforms to the measurements and use of materials specified in the two-page instructions	75

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1	Number and type of expedient shelters constructed	5
2	Demographic characteristics of shelter construction participants	7
3	Materials used in construction of Door-Covered Trench Shelters	12
4	Problems in communication and construction encountered by four groups constructing the Door-Covered Trench Shelters	13
5	Materials used in construction of Log-Covered Trench Shelters	17
6	Problems in communication and construction encountered by three groups constructing the Log-Covered Trench Shelters	18
7	Materials used in constructing a Car-Over-Trench Shelter . . .	35
8	Problems in communication and construction encountered by two groups constructing the Car-Over-Trench Shelter	36
9	Materials used in constructing an Aboveground Door-Covered Shelter	39
10	Problems in communication and construction encountered by two groups constructing the Aboveground Door-Covered Shelters	40
11	Materials used in constructing a Crib-Walled Shelter	47
12	Problems in communication and construction encountered by two groups constructing the Crib-Walled Shelter	49
13	Materials used in constructing a Ridge-Pole Shelter	55
14	Problems in communication and construction encountered by two groups constructing Ridge-Pole Shelters	56
15	Materials used in constructing a Tilt-up Doors and Earth Shelter	64
16	Problems in communication and construction encountered by two groups constructing the Tilt-up Doors and Earth Shelter	65

<u>Table</u>		<u>Page</u>
17	Materials used in the construction of eight representative air pumps	69
18	Communication and construction problems encountered in building eight representative air pumps	70

FOREWORD

Cresson H. Kearny

Introduction

To further the development of improved instructions to enable average untrained Americans to build high-protection-factor expedient shelters,* the Oak Ridge National Laboratory entered into a subcontract agreement with Brigham Young University (BYU). The contract stipulated that BYU receive the entire sum paid by the Defense Civil Preparedness Agency (DCPA) to ORNL for field-testing its one-page shelter-building instructions and provided for construction of expedient shelters of seven different designs for a total of 17 shelters by 17 untrained families (or groups).

In order to obtain unbiased, independent conclusions and recommendations from the BYU professors who conducted the field tests, they were told only how in previous tests average American families had been motivated to build shelters under time-stressed conditions and that the final report should be written without submitting drafts for review. The professors are able and conscientious, but were admittedly working in an area outside their normal fields. Therefore, the BYU report reflects some oversights and includes a few technical errors.

Each of the 17 families was guided by a one-page instruction sheet prepared by DCPA. These one-page DCPA instructions are given at the end of this Foreword, along with the DCPA instructions for building an expedient air pump.

The introductory page supplied by DCPA, "These are Plans for Expedient Fallout Shelters," first mentions some ways that "shelters can be made more comfortable," and then lists "the minimum necessities." But no mention is made of the second most essential necessity of a shelter — an adequate supply of air — and since the only shelter

* Expedient shelters are defined in the civil defense community as those that can be built in 48 hr or less following field-tested designs and widely available materials.

furnishing most of the builders were required to make was a "Shelter Air Ventilation Pump," the introductory page was not given to the builders. The omission of an air pump among the listed minimum necessities would have reduced their motivation to make good models.

The author of the Foreword negotiated the subcontract, observed the construction of six shelters, and inspected three others after construction. His comments and recommendations, which supplement and reinforce those in the BYU report, are summarized in the following paragraphs.

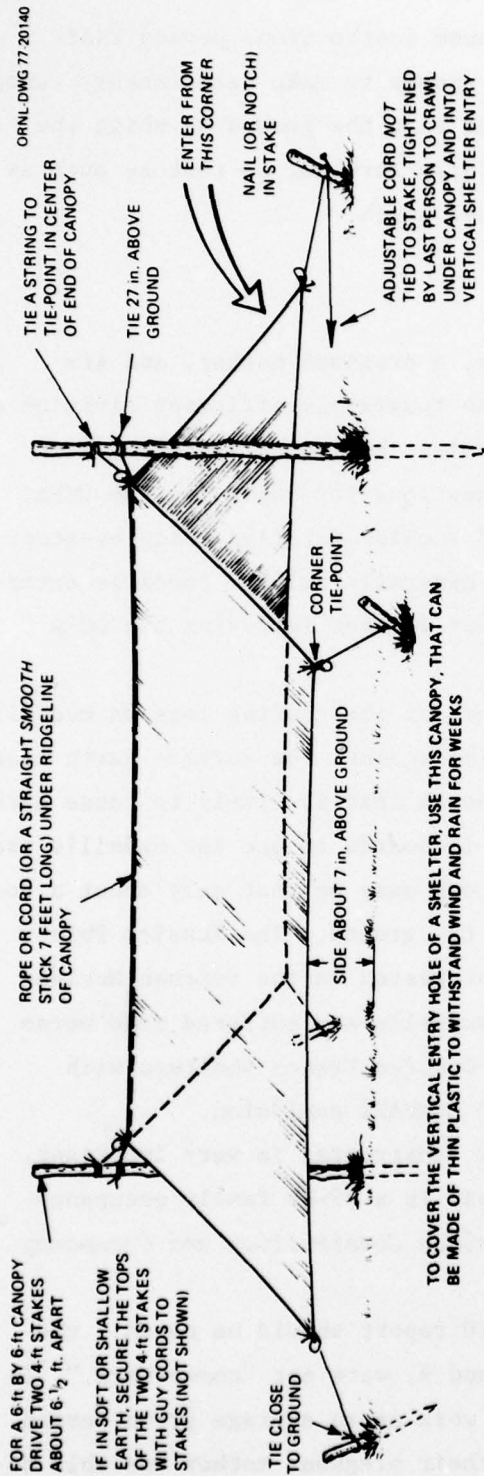
Specific Comments and Recommendations

Door-Covered Trench Shelter

1. The ventilation trench shown in the DCPA illustration is too small for the installation of a homemade ventilating pump or for use as an exhaust duct in hot weather. The improved ORNL design of the Log-Covered Trench Shelter, which a six-person family had no difficulty living in continuously for 77 hr in the Utah summer, had a crawlway emergency exit-ventilation duct of adequate size, 24 by 24 in. in vertical cross section. This is the minimum size that should be incorporated in the DCPA plans for a Door-Covered Trench Shelter (see ORNL-5039, *Expedient Shelter Construction and Occupancy Experiments*).

2. Canopies over the vertical entrances and vertical ventilation openings of this and other types of shelters were all made of the ordinary 4-mil polyethylene film. As is emphasized in the BYU report, not one of the builders made a canopy that stood up under the rain and wind to which it was exposed for several days following construction.

Subsequent to the BYU tests, improved models of canopies were designed, built, and tested by the author. The best model (which utilizes only 4-mil polyethylene film, cord, string, and stakes) withstood high winds, rain, and a garden hose turned full-force on it, and remained a serviceable canopy after a 21-day test in Colorado. Figure F.1 is a copy of the field-tested instructions for making a satisfactory canopy. Note that these instructions require as much space to print as do the one-page DCPA instructions for building a complete shelter. But field



DIRECTIONS:

1. CUT A PIECE OF PLASTIC 6 1/2 ft. BY 6 1/2 ft., TO MAKE A 6 ft. BY 6 ft. CANOPY. USE PLASTIC AT LEAST 4 MILS THICK.
2. TO MAKE DURABLE TIE POINTS AT THE FOUR CORNERS AND AT THE CENTERS OF THE TWO ENDS, SMOOTHLY CUT TABS OUT OF THE SIDES - AS INDICATED BY SKETCH OF ONE END, ON RIGHT.
3. MARK AND "X" ON EACH TAB, AS SHOWN.
4. SELECT 6 PEBBLES OR LUMPS OF EARTH EACH ABOUT 3/4 INCH IN DIAMETER.
5. WITH THE STRONG PIECE OF STRING THAT WILL BE USED TO CONNECT A TIE POINT TO A STAKE, TIE A PEBBLE IN THE TAB SO THAT THE PEBBLE IS COMPLETELY COVERED AND THE "X" MARK IS OUTERMOST. SEE SKETCHES.
6. MAKE 6 TIE POINTS IN THIS MANNER, EACH WITH A STRING ATTACHED.
7. PITCH THE CANOPY AS ILLUSTRATED ABOVE, WITH ITS TWO SIDES EACH ABOUT 7 INCHES ABOVE THE GROUND.

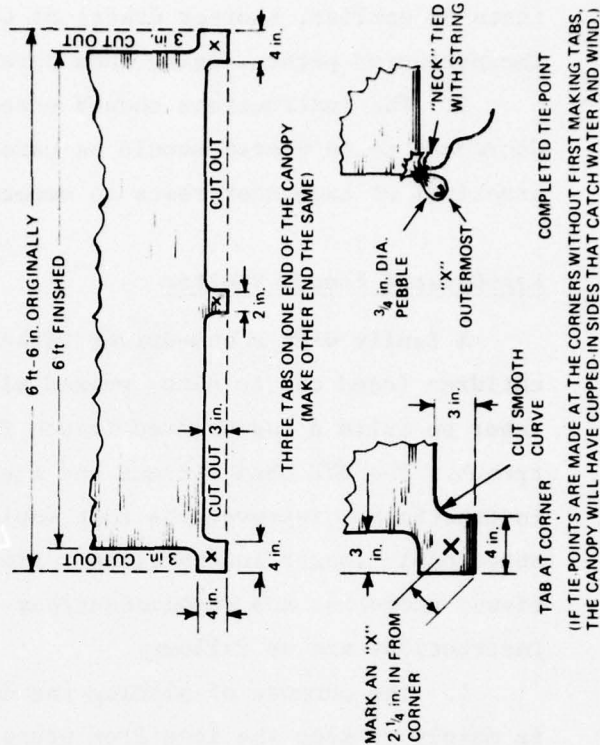


Fig. F.1. Field-tested instructions for making a shelter-entry canopy.

tests of earlier, shorter drafts of these instructions proved that inexperienced persons using them were unable to make satisfactory canopies.

3. The instructions should stress that the ground on which the doors are to be placed should be carefully leveled, so that as much as practical of each door rests on smoothed earth.

Log-Covered Trench Shelter

A family with a bus-driver father, a pregnant mother, and six children (aged one to nine) worked with remarkably efficient division of labor to build a Log-Covered Trench Shelter having a 22-ft-long main trench. The BYU observations and suggestions for improving the DCPA instructions — improvements that would require detailed, step-by-step, unavoidably longer instructions — are generally valid. Specific exceptions, comments, and recommendations for further improving the DCPA instructions are as follows:

1. The purpose of placing the ends of the roofing logs on mudsills is mainly to keep the logs from pressing against the surface earth near the edges of the trench, exerting pressure that is likely to cause earth to cave off the sides of the trench. If boards to use for mudsills are lacking, at least the earth should be dug away so that only about a foot at each end of each 7-ft log rests on the ground. The Russian Pole-Covered Trench Shelters that were blast tested in the Defense Nuclear Agency's DICE THROW explosion lacked mudsills and suffered much worse sidewall caving-off than the ORNL Log-Covered Trench Shelters with mudsills that were tested in the MIXED COMPANY explosion.

2. A ventilation trench properly constructed is very important. For one that has been proved serviceable in a 77-hr family occupancy test in hot weather, see *Expedient Shelter Construction and Occupancy Experiments*, ORNL-5039.

3. An error in Table 5 of the BYU report should be noted: the four oldest children, aged, 5, 6, 7, and 9, were not "nonworkers." In fact, together they did about as much work as an average grown person could have done — somewhat more than their pregnant mother was able to accomplish by making a major effort.

4. To cover the roof logs and prevent earth from falling through the cracks, bed sheets, curtains, or plastic film should be listed as the preferred coverings; newspapers should be recommended only if stronger materials are not available.

5. Nails should be listed as useful, but not essential, for building this shelter and/or suspending bed-sheet hammocks and bed-sheet chairs.

Car-Over-Trench Shelter

As compacts and minicompacts become more numerous, the practicality of this last-resort expedient shelter will be further reduced.

Above-Ground Door-Covered Shelter

Of particular significance is the need for the instructions to emphasize that when making an earth roll, the cloth should be pulled tight before the upper, outer side of the cloth is formed into a "hook" and filled with packed earth.

Crib-Walled Shelter

1. Under the section Feasibility, the BYU report is in error in stating that a Crib-Walled Shelter requires the use of earth that "can be rather densely compacted." The cribs can be filled with any earth, although, of course, the denser the earth, the better.

2. For the cribs, many household materials besides sheets (curtains, bedspreads, tablecloths, plastic film, etc.) can be used. As recommended under the BYU Suggestions for Improvements, these should be listed.

Ridge-Pole Shelter

1. The BYU observations and suggestions are correct. The need to give average Americans simplified information about the nature of fallout radiation and the essentials of good shielding materials should certainly be emphasized.

2. Fortunately, for the practicality of shelters dependent for shielding on steeply sloping earth coverings, in most areas where the surface soil is usually dry and subject to wind erosion, the water table is low enough to permit the construction of belowground trench shelters. However, how to prevent serious blast wind or natural wind erosion of steeply inclined dry earth covering a shelter is an unsolved problem.

3. Earlier instructions for building this shelter specified that the full thickness of earth covering for a rather steeply sloping shelter roof should be placed first at ground level and then piled successively higher and higher up the roof while maintaining full thickness. Builders of Ridge-Pole Shelters following these instructions experience no difficulties in keeping earth on the roof.

Tilt-up Doors and Earth Shelter

1. The BYU evaluation of the feasibility of untrained citizens constructing this type of shelter is generally sound, but improved instructions should include both a warning on the vulnerability of this shelter to fire and/or blast, and an explanation of the fact that, if built leaning against the side of an average house, the protection factor (PF) of the shelter is much lower than the PFs of the six other types of expedient shelters built in Utah.

2. The efforts of the hardworking divorcee and her four children, who built a Tilt-up Doors and Earth Shelter, were observed by the author. This shelter used 13 (not 6) doors. (If these builders had made their shelter the specified length for five persons, then "only" 11 doors would have been required.) Many homes do not have a sufficient number of doors to build a Tilt-up Doors and Earth Shelter, a design that requires as many doors as a Door-Covered Trench Shelter or an Aboveground Door-Covered Shelter large enough for the same number of occupants.

3. This Tilt-up Doors and Earth Shelter was built with the upper ends of its doors resting on a lower part of the rock wall serving as the foundation of a mobile home. This part of the wall was so low that the doors were positioned dangerously, at too low an angle and so bowed and insecure that the builders decided not to go into their finished

shelter. The BYU civil engineer who observed the structural safety aspects of the BYU experiments agreed with the judgment of the builders and stayed outside of this insecure shelter. The BYU professors, who were not at the site when this shelter was completed, obviously did not realize that this shelter, built against the remaining available part of the mobile home building, was unsafe, although it did not collapse.

Construction of Air Pumps

1. In numerous pump-building field tests, the author had observed practically all the difficulties experienced by the BYU pump builders — plus several more. Several years ago the author of this Foreword and the inventor of this air pump had first tried to develop brief instructions for building and using this novel air pump. In the end, in order to enable average citizens to build and use this "Punkah Pump" — later renamed the Kearney Air Pump (KAP) by the Office of Civil Defense — step-by-step instructions had to be written that were much longer and included numerous illustrations, plus explanations as to the "whys" of the pump's parts, its proper installation, and its operation. Yet even the resultant much-tested instructions (see ORNL/TM-3916) should be improved by adding some additional guidance, including how to attach cabinet hinges to the edge of a board, so that the pump swings properly when this board is nailed to the low shelter roof of a stoop-in shelter entry or a crawlway air duct.

2. Following the DCPA instructions, only four of the nine groups of BYU builders of an expedient pump succeeded in making a pump that, if operated with a restricted swing, worked fairly well. Not one of the BYU builders properly attached a pair of metal hinges to a pump frame and a supporting board so that the pump could swing 180°, or be vigorously operated without tearing the hinges loose or breaking them. Six of the nine pumps easily could have been improved so as to make them effective, if only the builders had been informed what was required.

3. In an independent test conducted by the author in Colorado later in 1977, a family was paid to follow the DCPA instructions. This family built a satisfactory KAP, except they could not determine how to

attach the cabinet hinges. Likewise, of three persons questioned separately by the author in Utah concerning how to attach metal hinges, not one succeeded in following the DCPA instructions. Yet persons following the instructions given in ORNL/TM-3916, which contains a separate sketch clearly showing how to attach ordinary hinges in a most unusual way so that a KAP can be swung properly, have no trouble with this critical feature.

4. The instructions in ORNL/TM-3916 already provide other essential guidance lacking in the much shorter DCPA pump-building instructions, including how large a pump to make so that it fits properly when installed in available openings and how to provide alternate positions for installing the pump so that air can always be pumped in the same direction as the natural flow of air through the shelter caused by the wind direction outside.

Appendix A

The BYU recommendations for total pay to future possible builders of the seven expedient shelters appear realistic if average American families are to be motivated to attempt this hard work and if the shelters are to be approximately the same sizes as those built in Utah in 1977. However, in the likely event that larger shelters of the more complicated designs were desired, a better rule of thumb would be to offer a total incentive of about \$125 (in 1977 dollars) for each occupant of an adequately large shelter, plus remuneration for all materials supplied by the shelter-building families.

Appendix C

The BYU-suggested revision of the instructions for the Door-Covered Trench Shelter is an improvement over the instruction sheet supplied by DCPA and used in BYU shelter-building tests. However, no instructions should be considered an improvement or ready for mass distribution during a possible crisis until they in turn have been thoroughly field-tested.

Based on observation of some two-score untrained families building expedient shelters and shelter ventilating pumps, the author concludes that average Americans, when attempting to build something novel, want and need detailed step-by-step instructions that tell them what to do next, how to do it, and why — if the reason is not obvious. If the BYU families had had detailed, step-by-step, well-illustrated instructions, they would have built better shelters and much better shelter ventilating pumps — and in less time. The records in the BYU report show that the Utah families spent an average total time of 88 min per shelter consulting the instructions. The average number of times that a worker or workers stopped work to consult the instructions was 18 times per shelter. Most of the time that the BYU builders spent consulting the instructions was in trying to interpret them and to determine what to do in what order. Time lost in correcting mistakes, most of which could have been avoided with step-by-step, more-detailed instructions, was not recorded by the BYU observers.

An Observation on Serious Limitations on the Building of a Good Expedient Shelter During a Crisis

A Mexican-American family was observed refusing to attempt to build a Ridge-Pole Shelter, after having signed an agreement with BYU and having gotten together food, water, and the very few tools in their modest home, preparatory to leaving for the shelter-building site early on the agreed day. When members of this family received the plans and learned that building their shelter would require the cutting of numerous poles, they realized that their complete lack of any wood-cutting tool, even a hatchet, made the job impossible. So they prudently refused to attempt the construction.

Many poor families lack tools and therefore would be unable to build the types of high-PF shelters that require the cutting of poles or lumber — unless they could obtain tools not available in their homes. Most apartment dwellers also lack efficient tools. Fortunately, many Americans, if adequately motivated, could dig simple trenches with sticks and other improvised tools, including buckets, pots, and cans,

and provide for themselves much better fallout protection than is afforded by most homes. People should be motivated to build high-PF shelters affording considerable protection against blast and good protection against fire. Therefore, the protection afforded by each type of shelter against radiation, blast, and fire should be clearly stated in the instructions for building that shelter.

Principal Recommendation

The author of this foreword and his civil defense associates at ORNL believe that during an escalating crisis threatening nuclear attack on the United States, the newspapers would not limit, as they do in normal times, the space devoted to the publication of survival information. Therefore, shelter-building instructions and other instructions intended for crisis distribution should not be arbitrarily limited to about the equivalent of one typed page per item described. Such instructions should be designed and then improved by field-testing to enable a very large fraction of the population to build good survival items in minimum time.

EXPEDIENT FALLOUT

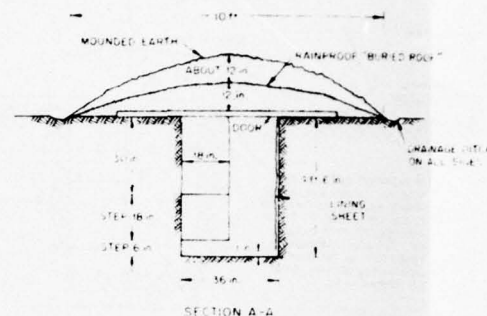
DOOR - COVERED TRENCH SHELTER

SELECT A REASONABLY LEVEL SITE. LAY OUT THE SHELTER AS ILLUSTRATED BY LAYING DOORS SIDE BY SIDE TO DETERMINE THE SHELTER LENGTH. DOOR KNOBS SHOULD BE REMOVED.



STEP 2 EXCAVATE THE SHELTER TRENCH, ENTRYWAY AND VENTILATION TRENCH AS SHOWN. PILE THE EXCAVATED EARTH AT LEAST 3 FEET BEYOND THE TRENCH LIMITS SO THAT IT WILL NOT INTERFERE WITH THE LATER PLACEMENT OF DOORS OVER THE TRENCH.

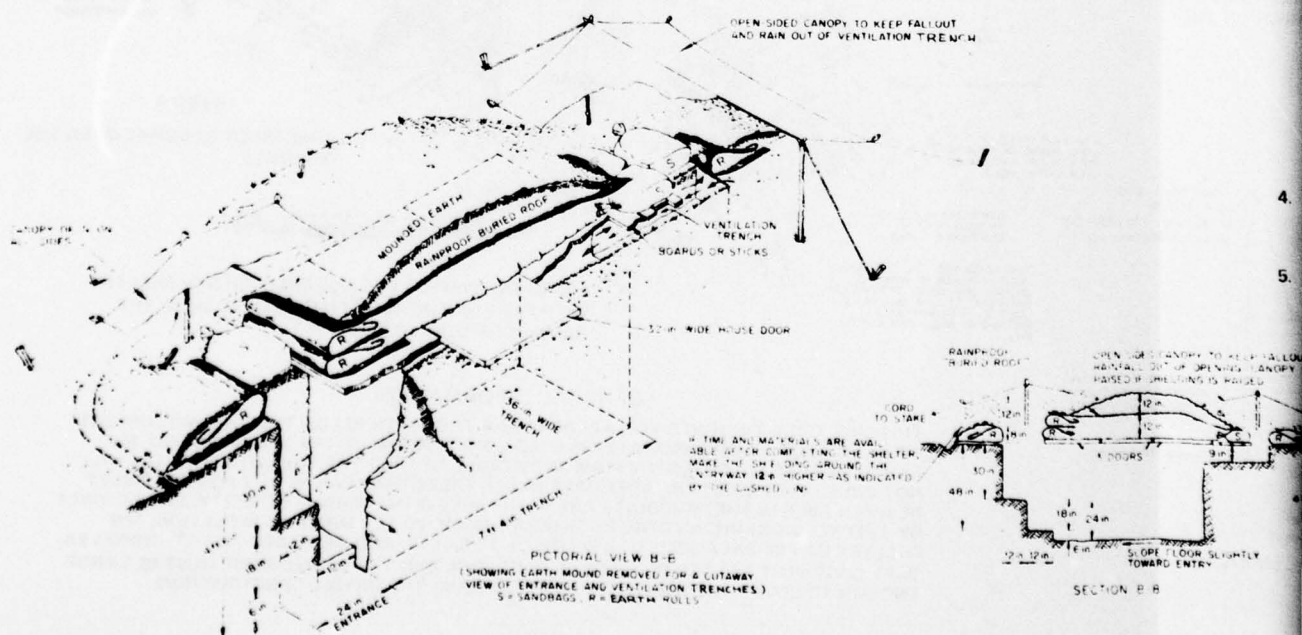
STEP 3 IF THERE ARE ADEQUATE SHEETS OR FABRIC AVAILABLE, LINE THE TRENCH WALLS WITH THEM. THEN PLACE DOORS OVER THE TRENCH.



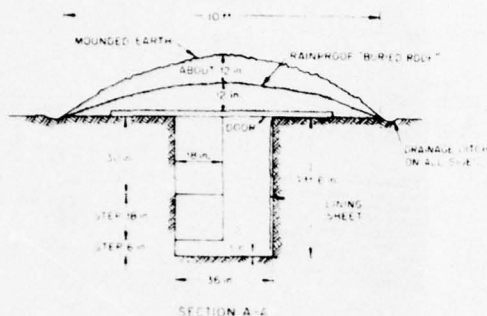
STEP 4 IN ORDER TO HOLD IN PLACE AN ADEQUATE AMOUNT OF EARTH ON TOP OF THE DOORS, CONSTRUCT EARTH "ROLLS" AROUND THE ENTRY-WAY AS SHOWN. THE "ROLLS" WILL KEEP THE EARTH FILL IN PLACE. SEE HOW TO MAKE AN EARTH ROLL.

STEP 5 PLACE EARTH FILL AND THE WATERPROOFING MATERIAL OVER THE DOORS. PLACE SANDBAGS AS SHOWN ON THE ILLUSTRATIONS.

STEP 6 CONSTRUCT SHALLOW DRAINAGE DITCHES ON ALL SIDES AND PLACE CANOPIES OVER THE OPENINGS



OUT THE SHELTER AS
Y SIDE TO DETERMINE
OULD BE REMOVED.



RODS OR STICKS
ENDING OF VENTILATION
ENCLOSURE 9 in. DEEP

VENTILATION TRENCH ABOUT
2 in IF NO BOARDS OR
IF AVAILABLE

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YOND THE TRENCH
WITH THE LATER
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**ETS OR FABRIC
WALLS WITH
ENCH.**

STEP 4 IN ORDER TO HOLD IN PLACE AN ADEQUATE AMOUNT OF EARTH ON TOP OF THE DOORS, CONSTRUCT EARTH "ROLLS" AROUND THE ENTRY-WAY AS SHOWN. THE "ROLLS" WILL KEEP THE EARTH FILL IN PLACE. SEE HOW TO MAKE AN EARTH ROLL.

STEP 5 PLACE EARTH FILL AND THE WATERPROOFING MATERIAL OVER THE DOORS. PLACE SANDBAGS AS SHOWN ON THE ILLUSTRATIONS.

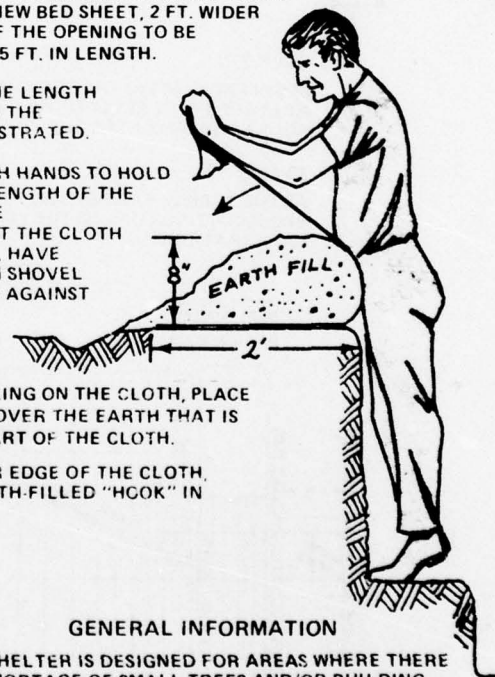
STEP 6 CONSTRUCT SHALLOW DRAINAGE DITCHES ON ALL SIDES AND PLACE CANOPIES OVER THE OPENINGS

TOOLS AND MATERIALS

1. DOORS (INTERIOR SOLID OR HOLLOW-CORE) – 1 FULL SIZE (32" MINIMUM WIDTH) FOR EACH PERSON. IF DOORS MEASURE LESS THAN 32" IN WIDTH, USE A COMBINATION OF DOORS TO PROVIDE THE MINIMUM WIDTH PER PERSON.
2. PICK AND/OR MATTOCK.
3. LONG-HANDLED SHOVELS.
4. RAINPROOFING MATERIAL – (e.g., PLASTIC SHEETING, CANVAS, PLASTIC TABLE COVERS, ETC.) AT LEAST 25 SQUARE FEET PER PERSON PLUS 2 PIECES ABOUT 6 FT. by 6 FT. FOR USE AS CANOPIES.
5. ONE BEDSHEET OR THE EQUIVALENT OF 50 SQ. FT. OF CLOTH OR PLASTIC PER PERSON TO LINE TRENCH AND MAKE EARTH-FILLED ROLLS.
6. TWO PILLOWCASES PER PERSON TO USE AS SANDBAGS
7. STRING OR CORD TO TIE CANOPIES AND SANDBAGS.
8. KNIFE.
9. SEVERAL BOARDS ABOUT 3 FEET LONG.
10. MEASURING TAPE AND/OR RULER.
11. WORK GLOVES FOR EACH WORKER.

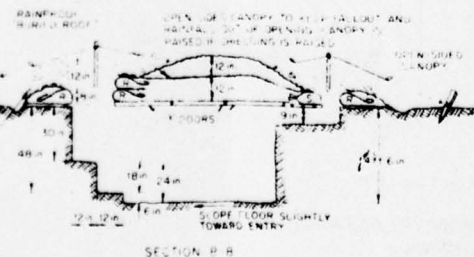
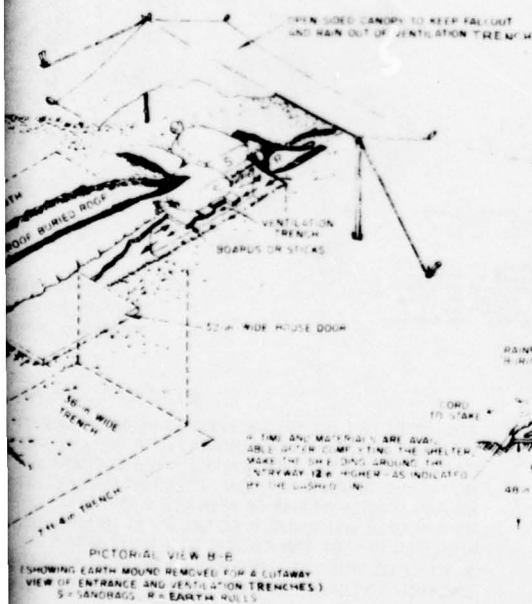
HOW TO MAKE AN EARTH ROLL

1. SELECT A PIECE OF CLOTH OR PLASTIC AT LEAST AS STRONG AS A NEW BED SHEET, 2 FT. WIDER THAN THE SIDE OF THE OPENING TO BE PROTECTED, AND 5 FT. IN LENGTH.
2. PLACE 2 FT. OF THE LENGTH OF THE CLOTH ON THE GROUND, AS ILLUSTRATED.
3. WHILE USING BOTH HANDS TO HOLD UP 3 FT. OF THE LENGTH OF THE CLOTH AND WHILE PRESSING AGAINST THE CLOTH WITH YOUR BODY, HAVE ANOTHER PERSON SHOVEL EARTH ONTO AND AGAINST THE CLOTH.
4. WHILE STILL PULLING ON THE CLOTH, PLACE THE UPPER PART OVER THE EARTH THAT IS ON THE LOWER PART OF THE CLOTH.
5. COVER THE UPPER EDGE OF THE CLOTH, FORMING AN EARTH-FILLED "HOOK" IN THIS EDGE.



GENERAL INFORMATION

THIS SHELTER IS DESIGNED FOR AREAS WHERE THERE IS A SHORTAGE OF SMALL TREES AND/OR BUILDING MATERIALS. THE DEPTH TO GROUND WATER AND ROCK MUST ALSO BE BELOW THE BOTTOM OF THE TRENCH. IN ADDITION, THE EARTH MUST BE SUFFICIENTLY FIRM AND STABLE SO THAT THE TRENCH WALLS WILL NOT COLLAPSE. THE SHELTER (3-PERSON CAPACITY) CAN BE CONSTRUCTED BY 3 PEOPLE WORKING AN APPROXIMATE TOTAL OF 18 HOURS EACH. READ AND STUDY ALL INSTRUCTIONS BEFORE BEGINNING TO BUILD.

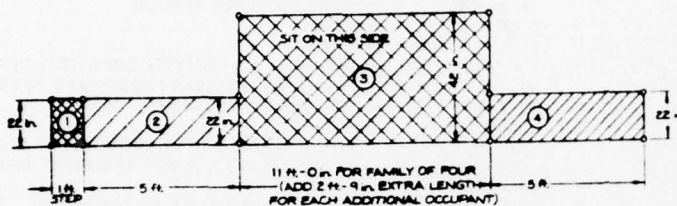


EXPEDIENT FALLOUT SH

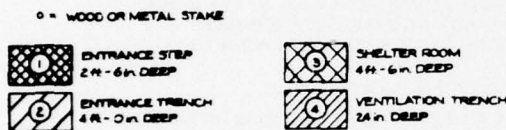
LOG—COVERED TRENCH SHELTER

STEP 1

CLEAR AREA OF BRUSH AND TALL GRASS.
LAYOUT SHELTER AS SHOWN BELOW.



LEGEND:

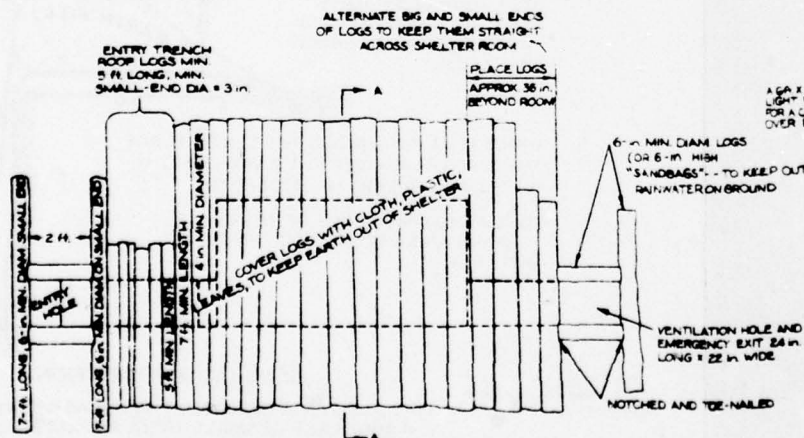


STEP 2

BEGIN EXCAVATING THE TRENCH. PLACE EXCAVATED EARTH
AT LEAST 3 FEET BEYOND THE EDGE OF TRENCH SO THAT THE
ROOF LOGS CAN LATER BE PLACED OVER THE TRENCH.

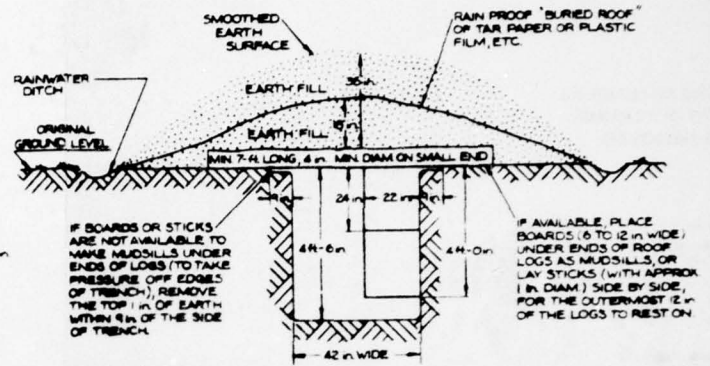
STEP 3

AS THE TRENCH EXCAVATION PROGRESSES, SOME WORKERS SHOULD
BEGIN CUTTING LOGS TO THE LENGTH AND SIZE AS SHOWN ON THE
ILLUSTRATIONS.



ROOF LOGS - MINIMUM 7-FT LONG, 4-IN. MINIMUM DIAMETER ON SMALL END
LAID ABOUT 2 ft. PAST EACH END OF SHELTER ROOM.

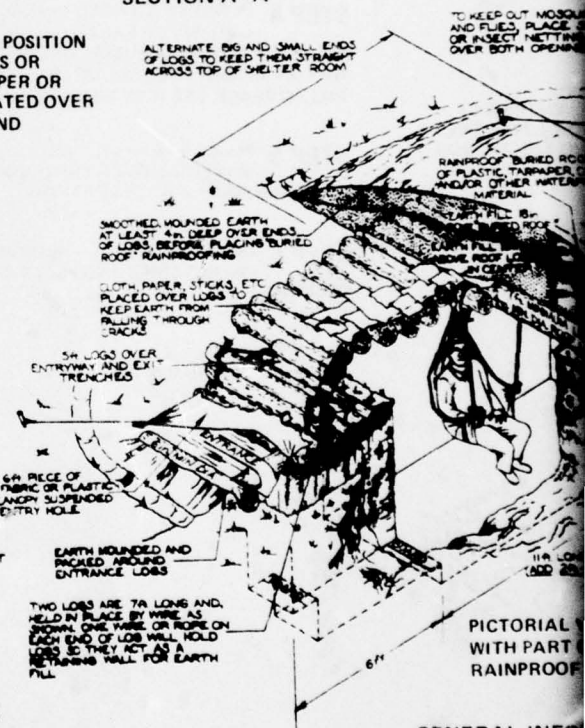
PLAN VIEW OF TOP OF SHELTER - SHOWING PLACEMENT
OF LOGS FOR ROOF-EARTH FILL NOT SHOWN



STEP 4

PLACE LOGS OVER TRENCH. POSITION
TIES FOR BED, SHEET CHAIRS OR
HAMMOCKS. PLACE NEWSPAPER OR
OTHER MATERIAL AS INDICATED OVER
LOGS. PLACE EARTH FILL AND
BURIED ROOF.

SECTION A-A



GENERAL INFO

THIS SHELTER IS DESIGNED FOR AREAS WHERE
TO HARD ROCK OR GROUNDWATER IS BELOW THE
EARTH MUST BE SUFFICIENTLY FIRM AND STABLE
NOT CAVE IN. IN ADDITION, ADEQUATE SMALL
BE AVAILABLE IN THE IMMEDIATE AREA. THE
BY 4 PEOPLE WORKING A TOTAL OF 18 HOURS
SHELTER CAN BE ENLARGED TO A WIDTH OF 5
9-FT LOGS MUST BE USED IN PLACE OF 7-FT LOGS
ENOUGH TO COVER THE WIDENED SHELTER DU

1. SAW AND/OR AXE.
2. PICK OR MATTOCK.
3. LONG-HANDLED SHOVELS.
4. RAINFOOTPROOFING MATERIAL (PLASTIC OR POLYETHYLENE) 25 SQUARE YARDS. FOR EACH PERSON ABOVE 4, ADD 2 SQ YDS.
5. 50 FEET OF STRONG STRING OR CORD AND A KNIFE.
6. TAPE MEASURE OR YARD STICK.
7. AT LEAST 8 PILLOW CASES AND/OR SANDBAGS.
8. WORK GLOVES.
9. BED SHEETS FOR USE AS "CHAIRS" OR "HAMMOCKS" – 1 PER PERSON PLUS AT LEAST 15 FEET OF STRONG ROPE OR CORD PER BED SHEET.
10. 15 POUNDS OF NEWSPAPERS TO PLACE OVER ROOF LOGS TO KEEP EARTH FROM FALLING THROUGH CRACKS BETWEEN LOGS.



ING PLACEMENT



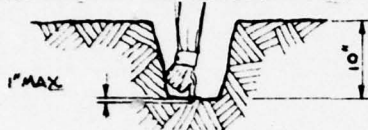
CONSTRUCT CANOPIES OVER THE OPENINGS.

2

EXPEDIENT FALLOUT CAR-OVER-TRENCH

STEP 1

SELECT A LEVEL SITE. DIG A SMALL TEST HOLE ABOUT 10 INCHES DEEP. REMOVE ALL LOOSE EARTH FROM THE BOTTOM. PUSH THE POINT OF YOUR THUMB INTO THE UNDISTURBED EARTH IN THE BOTTOM OF HOLE. IF YOU CANNOT PUSH YOUR THUMB DEEPER THAN ONE INCH, THE EARTH SHOULD BE SUITABLE FOR THIS SHELTER. IF THUMB PENETRATES DEEPER THAN ONE INCH, MOVE TO ANOTHER SITE AND REPEAT TEST, BECAUSE EARTH AT THE TESTED SITE IS NOT SUITABLE.



EARTH STABILITY TEST

STEP 3

EXCAVATE TRENCH AND ENTRYWAY. AS TRENCH DEEPENS, REPEAT EARTH STABILITY TEST ON BOTTOM OF TRENCH. IF EARTH BECOMES "SOFTER" DO NOT DEEPEN TRENCH. PLACE EXCAVATED EARTH AWAY FROM TRENCH SO THAT CAR CAN BE DRIVEN OVER TRENCH.

STEP 4

LINE TRENCH WITH PLASTIC OR CLOTH. LINING SHOULD TOUCH FLOOR OF TRENCH AND EXTEND OUTWARD TO THE LIMIT OF EARTH FILL. AFTER TRENCH IS LINED, CAREFULLY DRIVE CAR OVER TRENCH TO THE POSITION SHOWN. HAVE SOMEONE GUIDE THE DRIVER OVER THE TRENCH.

STEP 6

PLACE PLASTIC COVER OVER ENTRANCE AND VENTILATION OPENINGS. SECURE UNDER HOOD AND TRUNK LID.

STEP 8

BANK EARTH AROUND CAR TO HEIGHT OF 20 INCHES.

STEP 9

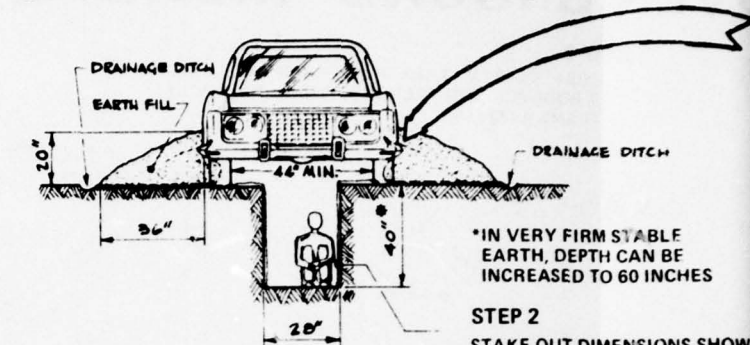
PLACE SANDBAGS AROUND ENTRANCE AND BANK EARTH AROUND THEM.

STEP 10

PLACE 3 INCHES OF EARTH ON CAR HOOD.

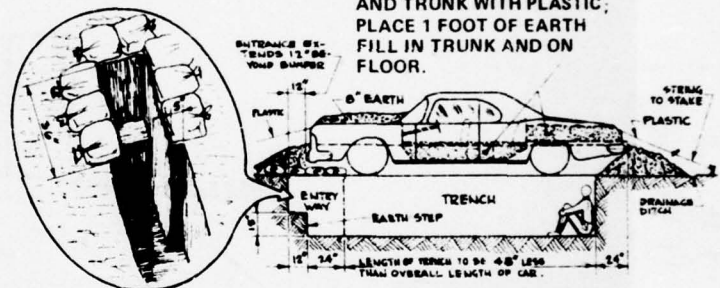
STEP 11

DIG SHALLOW DRAINAGE DITCH AROUND FILL.



TRENCH AND FILL DETAIL

STEP 5 REMOVE ALL SEATS (IF POSSIBLE). COVER FLOOR AND TRUNK WITH PLASTIC. PLACE 1 FOOT OF EARTH FILL IN TRUNK AND ON FLOOR.



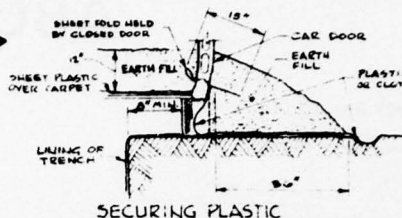
TRENCH AND ENTRYWAY DETAIL

STEP 7

SECURE PLASTIC TO SIDES OF CAR AS SHOWN HERE AND ABOVE. USE WOOD OR STICK WEDGES AT HOOD AND TRUNK TO HOLD PLASTIC. ALSO SECURE WITH DOOR AS SHOWN ABOVE.

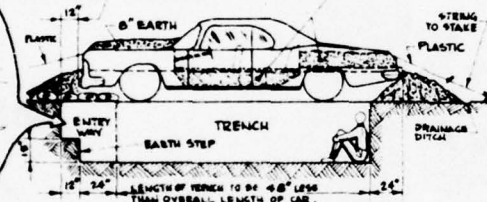
GENERAL INFO:
BEGINNING 11
FOR UP TO 6 P
BUILT IN AREA
SURFACE. SH
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OM OF HOLE.
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D REPEAT TEST,
S NOT SUITABLE.



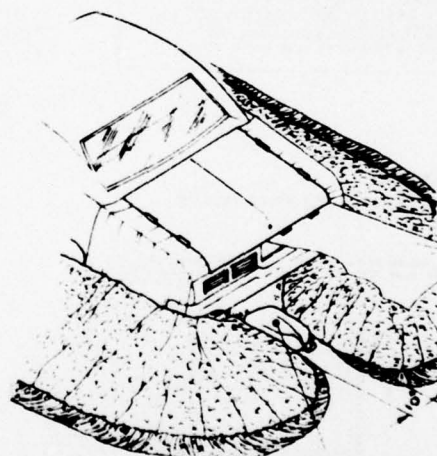
*IN VERY FIRM STABLE
EARTH, DEPTH CAN BE
INCREASED TO 60 INCHES

STAKE OUT DIMENSIONS SHOWN FOR TRENCH AND ENTRYWAY. NOTE THAT THE LENGTH OF TRENCH MUST BE 4 FEET LESS THAN THE OVERALL LENGTH OF THE CAR.



TRENCH AND ENTRYWAY DETAIL

1. CAR; CAUTION: CAR MUST HAVE AT LEAST 44 INCHES OF WIDTH BETWEEN INSIDE WALLS OF TIRES.
2. PICK AND LONG HANDLED SHOVEL.
3. PLASTIC SHEETING AND/OR CLOTH APPROX. 10-12 BEDSHEETS OR EQUIV. AREA OF OTHER MATERIALS WILL BE REQUIRED.
4. SANDBAGS, SACKS OR PILLOWCASES, 9 REQUIRED.
5. 50 FEET OF STRONG STRING OR CORD AND A KNIFE.
6. YARDSTICK OR MEASURING TAPE
7. WORK GLOVES FOR EACH WORKER.
8. STAKES, 4 REQUIRED.



**SANDBAG TO REDUCE AIRFLOW
WHEN REQUIRED DURING COLD
WEATHER**

SECURE PLASTIC TO SIDES
OF CAR AS SHOWN HERE AND
ABOVE. USE WOOD OR STICK
WEDGES AT HOOD AND TRUNK TO HOLD
PLASTIC. ALSO SECURE WITH DOOR AS
SHOWN ABOVE

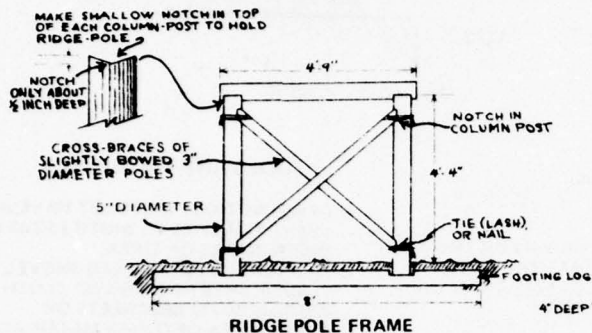
GENERAL INFORMATION: READ AND STUDY ALL INSTRUCTIONS BEFORE BEGINNING. IF A BIG STATION WAGON IS USED, SHELTER CAN BE PROVIDED FOR UP TO 6 PERSONS, LESS IF CAR IS SMALLER. THIS SHELTER CAN NOT BE BUILT IN AREAS WHERE GROUNDWATER OR ROCK IS CLOSE TO THE GROUND SURFACE. SHELTER CAN BE CONSTRUCTED BY TWO PERSONS WORKING A TOTAL OF ABOUT 12 HOURS EACH.

EXPEDIENT FALLOUT SH

ABOVE - GROUND RIDGE - POLE

STEP 1

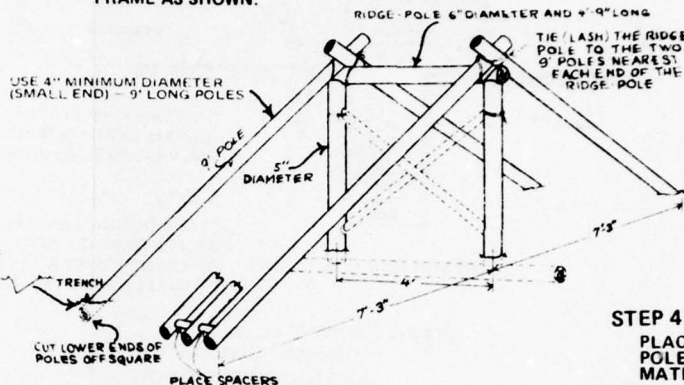
CONSTRUCT RIDGE POLE FRAME



SIDE VIEW SHOWING CROSS-BRACES OF COLUMN POSTS (IF LARGE NAILS ARE AVAILABLE, SIMPLY NAIL TWO SIMILARLY SLOPING CROSS-BRACES ON OPPOSITE SIDES OF THE COLUMN POSTS.) FOR SHELTERS WITH THREE OR MORE COLUMN POSTS USE ONLY ONE BRACE BETWEEN EACH PAIR OF POSTS AND SLOPE BRACES ALTERNATELY IN DIFFERENT DIRECTION.

STEP 2

DIG 4" DEEP "V" TRENCH IN EARTH AND PLACE 9' ROOF POLES IN TRENCH AND ON RIDGE-POLE FRAME AS SHOWN.



STEP 4

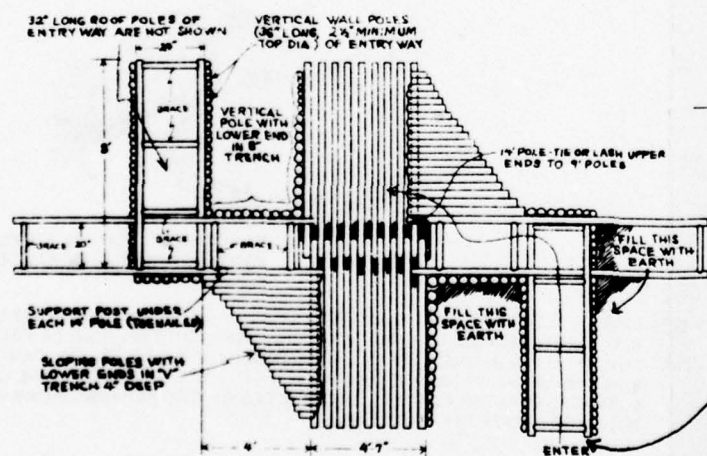
PLACE LIMBS OR STICK POLES. PLACE EARTH MATERIALS AS ILLUSTRATED.

AVOID CARRYING POLES - DRAG THEM

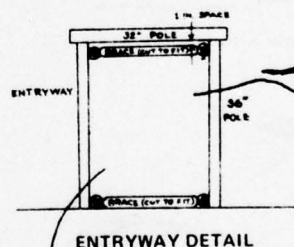


STEP 3

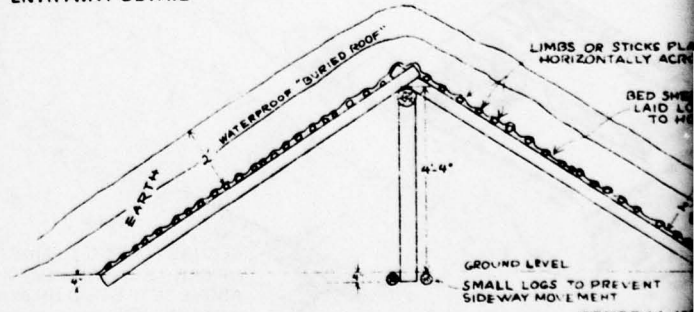
CONSTRUCT ENTRYWAYS



VIEW LOOKING DOWN ON SHELTER WITH ALL POLES IN PLACE EXCEPT THE ROOF POLES OF THE TWO ENTRYWAYS.



ENTRYWAY DETAIL



SECTION THRU COMPLETED SHELTER

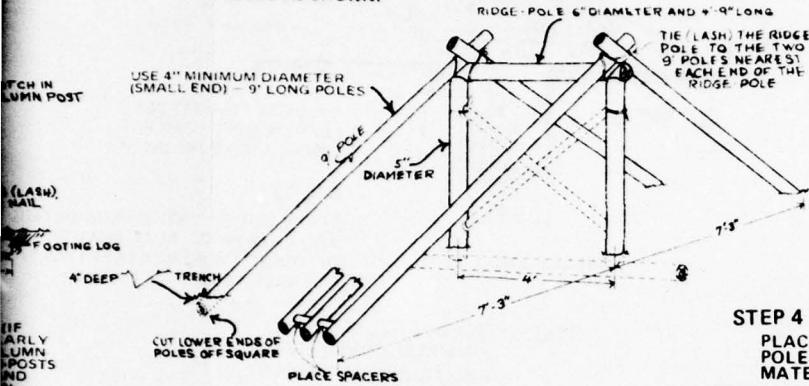
GENERAL INSTRUCTIONS
THIS SHELTER IS AN ABUNDANT SHELTER (CAPACITY) CAPABLE OF 24 HOURS BEFORE BEGINNING

ENT FALLOUT SHELTER

BOVE - GROUND RIDGE - POLE

STEP 2

DIG 4" DEEP "V" TRENCH IN EARTH AND PLACE 9' ROOF POLES IN TRENCH AND ON RIDGE-POLE FRAME AS SHOWN.

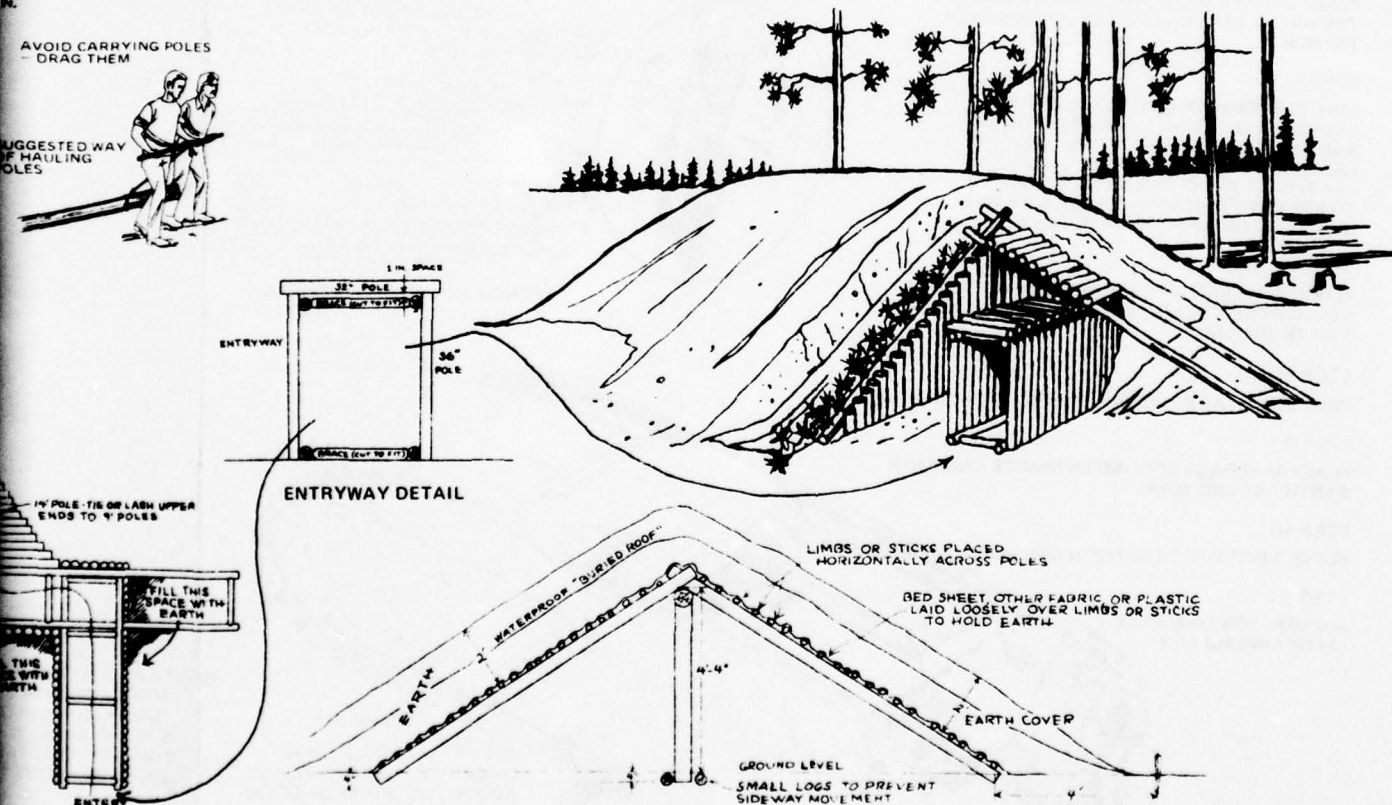


TOOLS AND MATERIALS

1. SAW TO CUT GREEN POLES (BOW OR CROSSCUT SAW PREFERRED), AND AN AXE.
2. SHOVEL (ONE SHOVEL FOR EACH TWO WORKERS).
3. LARGE BUCKETS, CANS, OR POTS WITH BAIL HANDLES TO CARRY EARTH.
4. KNIFE.
5. THREE DOUBLE-BED SHEETS FOR THE ILLUSTRATED 5-PERSON SHELTER, OR AN EQUIVALENT AREA OF EQUALLY STRONG FABRIC OR PLASTIC. ONE ADDITIONAL SHEET FOR EACH ADDITIONAL 2 OCCUPANTS. IF NOT AVAILABLE, USE STICKS AND SMALL POLES PLACED ACROSS THE 9-FT SIDE POLES AND COVER WITH GRASS OR LEAVES TO FILL IN THE SPACES BETWEEN THE POLES.
6. HAMMER AND AT LEAST 80 NAILS (3 IN. OR LONGER), OR AT LEAST 200 FT. OF ROPE OR STRONG WIRE, OR TWO ADDITIONAL BED SHEETS (OR OTHER FABRIC EQUALLY STRONG) FOR EACH PERSON TO BE SHELTERED TO MAKE INTO FOOT-WIDE STRIPS TO SERVE AS "ROPE" WHEN TWISTED.
7. AT LEAST 2 SQUARE YARDS PER PERSON OF RAIN-PROOFING MATERIAL (SHOWER CURTAINS, PLASTIC TABLE CLOTHS, PLASTIC MATRESS COVERS, ETC.) - ESSENTIAL IN RAINY COLD WEATHER.
8. GLOVES TO PREVENT INJURY AND BLISTERS TO HANDS.

STEP 4

PLACE LIMBS OR STICKS AND BEDSHEETS ACROSS ROOF POLES. PLACE EARTH FILL AND WATERPROOFING MATERIALS AS ILLUSTRATED.



SECTION THRU COMPLETED SHELTER

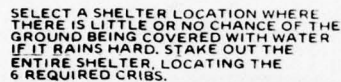
GENERAL INFORMATION

THIS SHELTER IS DESIGNED FOR AREAS WHERE THERE IS AN ABUNDANCE OF SMALL TREES AND BELOWGROUND SHELTERS ARE IMPRACTICAL. THE SHELTER (5-PERSON CAPACITY) CAN BE BUILT BY 5 PEOPLE WORKING A TOTAL OF 24 HOURS EACH. READ AND STUDY ALL INSTRUCTIONS BEFORE BEGINNING.

EXPEDIENT FALLOUT

CRIB-WALLED SHELTER-ABOVE GROUND

1. SAW AND/OR AXE TO CUT TREE POLES.
2. SHOVELS (ONE FOR EACH TWO WORKERS).
3. LARGE CANS, BUCKETS AND/OR POTS WITH BAIL HANDLES TO CARRY EARTH.
4. KNIFE OR SASS.
5. AT LEAST 300 FEET OF STRONG WIRE OR 300 FT OF ROPE, OR 8 DOUBLE-BED SHEETS (TO TEAR INTO 1-FOOT-WIDE STRIPS, TO SERVE AS ROPE WHEN SLIGHTLY TWISTED). FOR EACH ADDITIONAL PERSON ABOVE 5, 20 FT OF ROPE, OR 2 DOUBLE-BED SHEETS ARE REQUIRED.
6. AT LEAST 30 SQUARE YARDS, PLUS 2 SQUARE YARDS PER PERSON ABOVE 5, OF RAINFOOF ROOF MATERIALS (SHOWER CURTAINS, PLASTIC TABLE CLOTHS, PLASTIC MATRESS COVERS, ETC.).
7. 15 DOUBLE-BED SHEETS OR AN EQUAL AREA OF CLOTH OR PLASTIC AT LEAST AS STRONG AS BED SHEETS, 2 ADDITIONAL SHEETS PER PERSON ABOVE 5.
8. GLOVES TO PROTECT HANDS FROM INJURY AND BLISTERS, FOR EACH WORKER
9. 15 POUNDS OF NEWSPAPER FOR ROOF COVER.



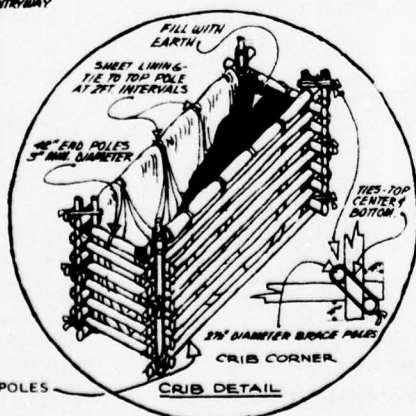
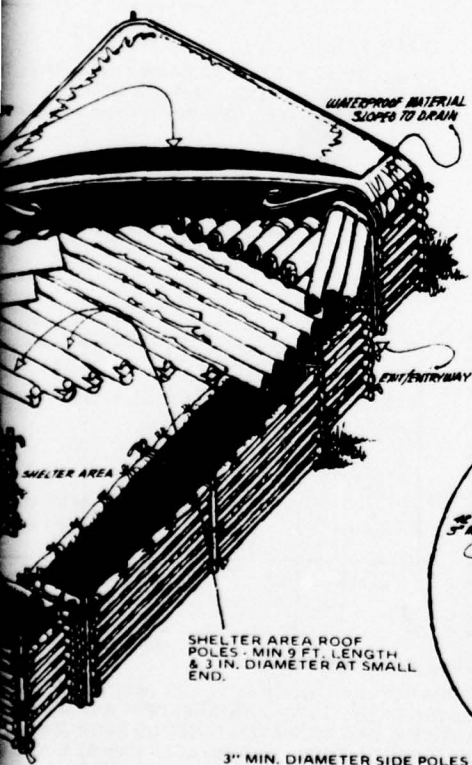
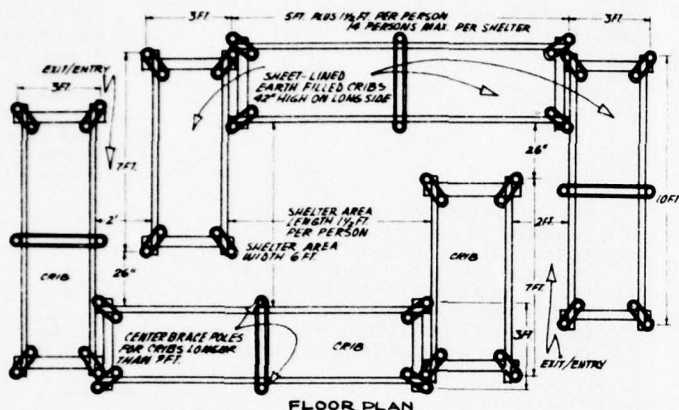
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AND
5 P
ALL

EXPEDIENT FALLOUT SHELTER

POLE-ENDED SHELTER-ABOVE GROUND

100 FT.
WITH
ROPE.
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PLASTIC
PERS. ETC.).
AREA OF
NG AS BED
PERSON
AND
COVER.

THE
R



STEP 2

CUT POLES HAVING TOPS WITH DIAMETERS (NOT INCLUDING BARK) NO SMALLER THAN THE DIAMETERS SPECIFIED ON THE ILLUSTRATION FOR EACH TYPE POLE.

STEP 3

SORT THE POLES BY SIZE (LENGTH AND DIAMETER) AND LAY ALL POLES OF EACH SIZE TOGETHER NEAR THE SHELTER SITE. CUT OFF ALL LIMBS SO THAT POLES ARE SMOOTH. DETERMINE IF ENOUGH LONG-SINGLE POLES CAN BE OBTAINED FOR THE SIDE-POLES OF THE 2 CRIBS ON THE LONG SIDES OF THE SHELTER. USUALLY, IF THE SHELTER IS TO BE BUILT FOR MORE THAN 7 PERSONS (15 1/2 FOOT POLES REQUIRED), IT IS BETTER TO USE 2 CRIBS PLACED END-TO-END INSTEAD OF ONE CRIB THAT REQUIRES THE LONGER POLES.

STEP 4

- PLACE TWO 3 1/2 FT. END-POLES ON THE GROUND AND PUT 2 OF THE THICKER SIDE-POLES ON TOP OF THE 2 END POLES SO THAT THE ENDS OF ALL 4 POLES STICK OUT 4" BEYOND WHERE THEY CROSS.
- STACK PAIRS OF END-POLES AND SIDE-POLES TO MAKE THE CRIB (WHILE KEEPING THE CRIB VERTICAL) TO A HEIGHT OF 42". TO KEEP THE TOP POLES OF THE CRIB LEVEL, ALTERNATE THE DIRECTION OF THE BIG AND SMALL ENDS OF THE POLES.
- PLACE A PAIR OF VERTICAL CORNER BRACE-POLES IN EACH OF THE 4 CORNERS OF THE CRIB. BRACE-POLES SHOULD BE CUT OFF AT THE SAME HEIGHT AS THE UPPER SIDES OF THE UPPER-MOST HORIZONTAL POLES TO WHICH THEY WILL BE TIED.
- TIE THE PAIR OF BRACE-POLES TOGETHER (AT BOTTOM, MIDDLE, AND TOP) USING 3-FT. LENGTHS OF WIRE, ROPE, OR TWISTED 1-FT-WIDE STRIPS OF CLOTH.
- IF THE CRIB IS MORE THAN 7 FT. LONG, PLACE A PAIR OF CENTER BRACE-POLES IN POSITION, ONE AGAINST THE OUTSIDE OF EACH LONG CRIB. TIE THE PAIR OF BRACE-POLES TOGETHER PERMANENTLY, JUST ABOVE THE GROUND. TEMPORARILY TIE EACH OF THEM TO THE UPPERMOST SIDE-POLE.
- LINE THE CRIB WITH CLOTH (OR PLASTIC FILM), MAKING SURE AT LEAST A FEW INCHES OF LINING HANGS OVER THE UPPERMOST POLES. TIE THE UPPER EDGE OF THE LINING TO THE UPPERMOST WALL-POLE EVERY 2 FT., AFTER FIRST CUTTING A SMALL HOLE THROUGH WHICH TO THREAD THE TIE-STRING OR A 4"-WIDE TIE-STRIP OF CLOTH.
- PERMANENTLY TIE TOGETHER THE CENTER BRACE-POLES USING HORIZONTAL TIES AT CENTER AND TOP.
- FILL THE LINED CRIB WITH EARTH FROM WHICH ALL GRASS, ROOTS, ETC., HAVE BEEN REMOVED.

STEP 5

PUT THE 9-FT. ROOF-POLES IN PLACE. PLACE THE STRONGEST POLES AT THE ENTRYWAYS, THEN PLACE THE SHORTER (5 TO 6 FT.) POLES OVER THE ENTRYWAYS.

STEP 6

TO KEEP EARTH FROM FALLING BETWEEN THE CRACKS OF THE ROOF, PUT STICKS IN THE LARGER CRACKS AND COVER THE ROOF WITH TWO OR MORE THICKNESSES OF NEWSPAPER OR OTHER MATERIAL.

STEP 7

PUT EARTH COVER ON THE ROOF TO THE DEPTHS SHOWN ON THE ILLUSTRATIONS. BE SURE TO SLOPE THE MOUNDED EARTH SURFACE DOWNWARD TOWARD THE EDGES SO THE ROOF WILL SHED WATER. USE BEDSHEETS TO FORM "EARTH ROLLS" AT THE ROOF EDGE. THE SHEETS WILL SERVE AS FORMS TO HOLD EARTH IN PLACE. CLUMPS OF TURF CAN BE SUBSTITUTED AT ROOF EDGES FOR THE BEDSHEETS. PLACE THE WATER PROOFING MATERIAL BEFORE PLACING THE FINAL 6 INCHES OF EARTH COVER.

STEP 8

IF THE WEATHER IS HOT, BUILD AND INSTALL A SHELTER VENTILATING PUMP. SEE SEPARATE INSTRUCTIONS ON VENTILATION FOR EXPEDIENT SHELTERS.

GENERAL INFORMATION

THIS SHELTER CAN BE CONSTRUCTED IN AREAS WHERE THERE IS AN ABUNDANCE OF SMALL TREES. THE APPROXIMATE AMOUNT OF TIME AND EFFORT REQUIRED TO BUILD THIS SHELTER (CAP. FOR 5) IS 5 PERSONS WORKING A TOTAL OF 24 HOURS EACH. READ AND STUDY ALL INSTRUCTIONS BEFORE STARTING TO BUILD.

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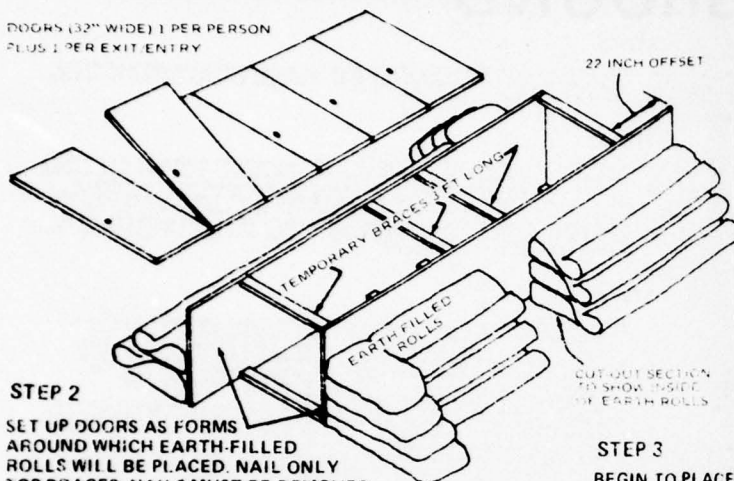
EXPEDIENT FALLOUT SHELTER

ABOVE-GROUND DOOR-COVERED SHELTER

TOOLS AND MATERIALS

1. Doors as indicated.
2. Pick or Mattock and Shovel.
3. Two Buckets or Large Can.
4. Tape Measure, Yardstick or Ruler.
5. Saw, Axe or Hatchet.
6. Hammer and at least 20 Nails.
7. At least 4 Double Bed Sheets.
8. Pillowcases and Rainproof Plastic or Polyethylene.
9. Work Gloves for Each Worker.
10. Lumber for use as Temporary Entry/Exit Frames.

DOORS (32" WIDE) 1 PER PERSON
PLUS 1 PER EXIT ENTRY



STEP 2

SET UP DOORS AS FORMS AROUND WHICH EARTH-FILLED ROLLS WILL BE PLACED. NAIL ONLY TOP BRACES. NAILS MUST BE REMOVED LATER. BRACE ALL CORNERS, CENTER, TOP AND BOTTOM OF EACH DOOR.

STEP 1

SELECT A SHELTER LOCATION WHERE THERE IS LITTLE OR NO CHANCE OF RAINWATER PONDING ON THE GROUND SURFACE. STAKE OUT SHELTER, REMOVE DOOR KNOBS. ALLOW 1 DOOR FOR EACH PERSON PLUS 1 DOOR FOR EACH ENTRY/EXIT AT BOTH ENDS. LIMIT IS 8 PERSONS PER SHELTER.

STEP 5

KEEP HEIGHT OF EARTH ABOUT EQUAL ON BOTH SIDEWALLS AS ROLLS ARE FORMED. AFTER SIDEWALLS HAVE REACHED PLANNED HEIGHT, REMOVE BRACES AND DOOR FORMS, USE SAME DOOR FORMS TO CONSTRUCT ENDWALLS WITH EARTH FILLED ROLLS. PROVIDE EXIT/ENTRY AT BOTH ENDS AS SHOWN.

STEP 3

BEGIN TO PLACE EARTH-FILLED ROLLS AGAINST DOOR FORMS. TO FORM EARTH ROLLS, SEE EARTH-FILLED ROLL DETAIL BOTTOM OF PAGE.

FOLD WATERPROOFING MATERIAL UNDER HIGHER EDGE OF DOOR TO KEEP IT FROM SLIPPING.

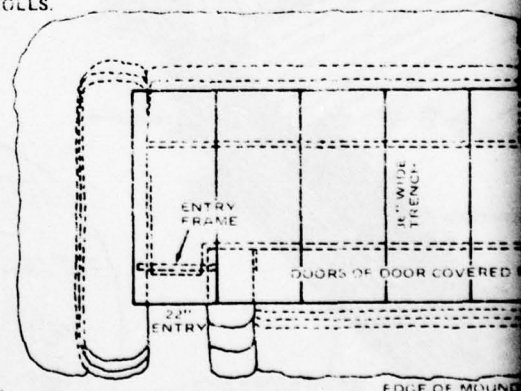
STEP 4

MOUND EARTH AGAINST THE EARTH FILLED ROLLS AS SHOWN. CONTINUE PLACING EARTH AND SHEETS TO FORM EARTH-FILLED ROLLS. CONTINUE PLACING EARTH AND SHEETS TO FORM EARTH-FILLED ROLLS.

STEP 8

PLACE 15 INCHES OF EARTH ON TOP OF SHELTER. IN HOT WEATHER CONSTRUCT A SHELTER VENTILATION AIR PUMP. SEE AIR PUMP DETAIL ON LAST PAGE.

PLAN VIEW OF SHELTER (LOOKING DOWN)



STEP 6

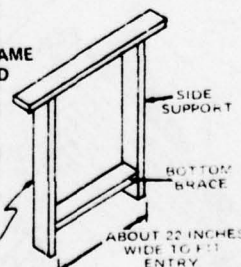
REMOVE DOOR FORMS FROM ENDWALLS. POSITION ROOF DOORS IN THEIR FINAL POSITION. PLACE ENTRY FRAME FOR DOOR OVER ENTRY/EXIT. PLACE WATERPROOFING MATERIAL ON DOORS.

STEP 7

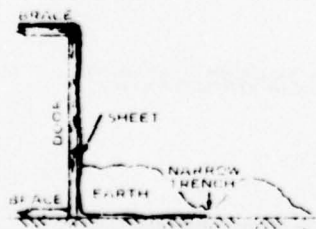
DIG 14" DEEP, 36" WIDE TRENCH INSIDE SHELTER. EARTH CAN BE PLACED DIRECTLY ONTO ROOF DOORS. TRENCH CAN BE MADE UP TO 3 FEET DEEP IF CONDITIONS PERMIT.

NOTE IF TRENCHING IS IMPRACTICAL HEIGHTEN WALLS BY USING ADDITIONAL EARTH ROLLS.

ENTRY/EXIT FRAME TWO REQUIRED



USE 2" x 4" BOARDS. SIZE TO FIT ENTRYWAY. MAKE AND INSTALL AFTER ENTRY IS COMPLETED.



EARTH-FILLED ROLL DETAIL

1. PLACE 2 FT OF SHEET ON GROUND AND TEMPORARILY DRAPE REMAINDER OF SHEET ON DOOR.
2. PLACE EARTH ON SHEET - SHAPE AS SHOWN.
3. FOLD SHEET OVER SHAPED EARTH.
4. PLACE EARTH ONTO SHEET AT NARROW TRENCH.
5. FOLD SHEET TO FORM EARTH HOOK. HOOK WILL ANCHOR SHEET.
6. REPEAT TO FORM NEXT EARTH-FILLED ROLL.

GENERAL INFORMATION

THE ABOVE-GROUND DOOR COVERED SHELTER IS FOR USE IN AREAS WHERE BELOW-GROUND SHELTERS ARE IMPRACTICAL BECAUSE OF THE GROUNDWATER TABLE OR BEDROCK. THE GROUND SURFACE. THIS SHELTER CAN BE BUILT BY PERSONS WORKING A TOTAL OF 12 HOURS EACH.

READ AND STUDY ALL INSTRUCTIONS BEFORE STARTING. IF DOOR WIDTHS MEASURE LESS THAN 32 INCHES, USE MORE DOORS TO PROVIDE A MINIMUM OF 32 INCHES OF DOOR WIDTH PER PERSON.

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FALLOUT SHELTER

DOOR-COVERED SHELTER

STEP 1

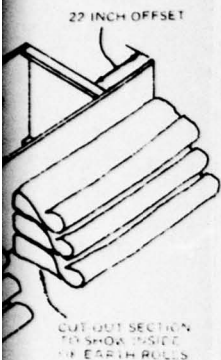
SELECT A SHELTER LOCATION WHERE THERE IS LITTLE OR NO CHANCE OF RAINWATER PONDING ON THE GROUND SURFACE. STAKE OUT SHELTER, REMOVE DOOR KNOBS. ALLOW 1 DOOR FOR EACH PERSON PLUS 1 DOOR FOR EACH ENTRY/EXIT AT BOTH ENDS. LIMIT IS 8 PERSONS PER SHELTER.

STEP 2

KEEP HEIGHT OF EARTH ABOUT EQUAL ON BOTH SIDEWALLS AS ROLLS ARE FORMED. AFTER SIDEWALLS HAVE REACHED PLANNED HEIGHT, REMOVE BRACES AND DOOR FORMS, USE SAME DOOR FORMS TO CONSTRUCT ENDWALLS WITH EARTH FILLED ROLLS. PROVIDE EXIT ENTRY AT BOTH ENDS AS SHOWN.

TOOLS AND MATERIALS

1. Doors as indicated.
2. Pick or Mattock and Shovel.
3. Two Buckets or Large Cans to Carry Earth.
4. Tape Measure, Yardstick or Ruler.
5. Saw, Axe or Hatchet.
6. Hammer and at least 20 Nails - 2 1/2" long.
7. At least 4 Double Bed Sheets for Each Person to be Sheltered.
8. Pillowcases and Rainproofing Materials such as Plastic or Polyethylene.
9. Work Gloves for Each Worker.
10. Lumber for use as Temporary Braces and for Entry/Exit Frames.



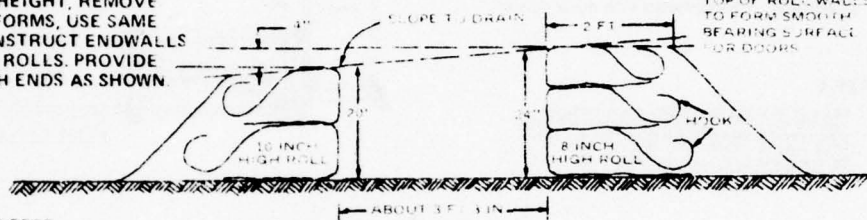
STEP 3

BEGIN TO PLACE EARTH-FILLED ROLLS AGAINST DOOR FORMS. TO FORM EARTH ROLLS, SEE EARTH-FILLED ROLL DETAIL BOTTOM OF PAGE.

FOLD WATERPROOFING MATERIAL UNDER HIGHER EDGE OF DOOR TO KEEP IT FROM SLIPPING.

STEP 4

MOUND EARTH AGAINST THE EARTH FILLED ROLLS AS SHOWN. CONTINUE PLACING EARTH AND SHEETS TO FORM EARTH-FILLED ROLLS. CONTINUE PLACING EARTH AND SHEETS TO FORM EARTH-FILLED ROLLS.

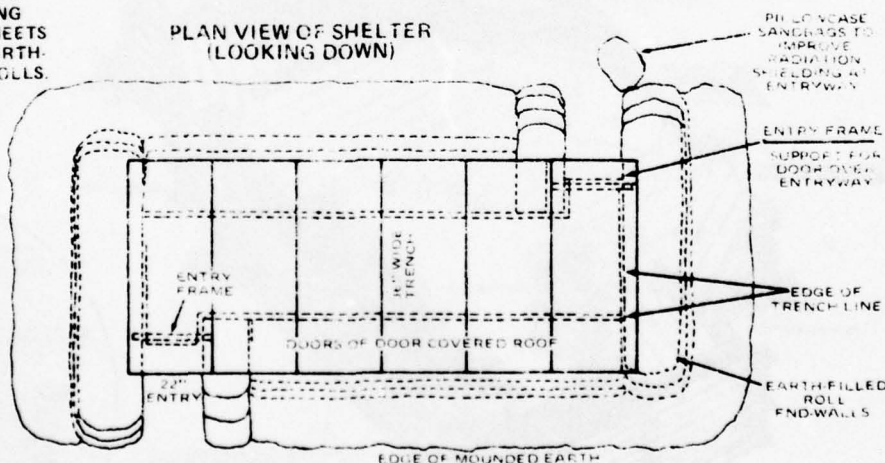


SHAPE EARTH ON TOP OF ROLL WALLS TO FORM SMOOTHER BEARING SURFACE FOR DOORS.

STEP 8

PLACE 15 INCHES OF EARTH ON TOP OF SHELTER IN HOT WEATHER CONSTRUCT A SHELTER VENTILATION AIR PUMP. SEE AIR PUMP DETAILS ON LAST PAGE.

PLAN VIEW OF SHELTER (LOOKING DOWN)



GENERAL INFORMATION

THE ABOVE-GROUND DOOR COVERED SHELTER IS DESIGNED FOR AREAS WHERE BELOW-GROUND SHELTERS ARE IMPRACTICAL BECAUSE THE GROUNDWATER TABLE OR BEDROCK IS CLOSE TO THE GROUND SURFACE. THIS SHELTER CAN BE BUILT BY FOUR PERSONS WORKING A TOTAL OF 12 HOURS EACH.

READ AND STUDY ALL INSTRUCTIONS BEFORE STARTING TO BUILD. IF DOOR WIDTHS MEASURE LESS THAN 32 INCHES, USE A COMBINATION OF DOORS TO PROVIDE A MINIMUM OF 32 INCHES OF DOOR-WIDTH PER PERSON.

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EXPEDIENT FALLOUT S TILT-UP DOORS AND EARTH

STEP 1

LAY OUT THE TRENCH AND EARTH NOTCH WIDTHS, AS DIMENSIONED ON THE SECTION BELOW, ADJACENT TO A MASONRY WALL. DETERMINE THE LENGTH OF TRENCH AND NOTCH BY ALLOWING 3 FEET OF LENGTH PER PERSON TO BE SHELTERED.

STEP 2

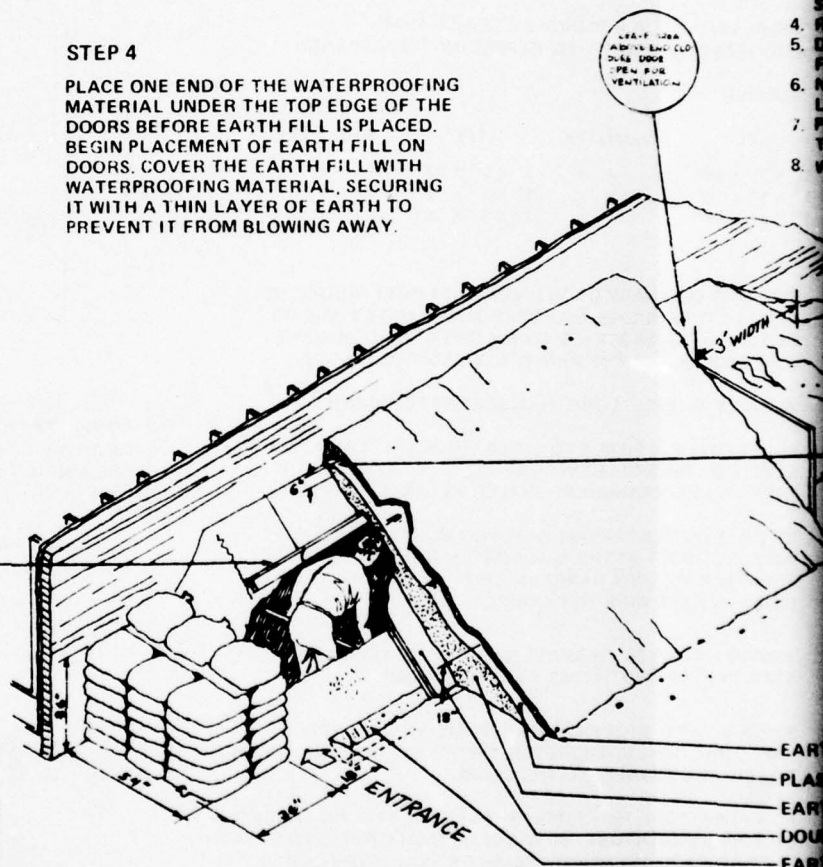
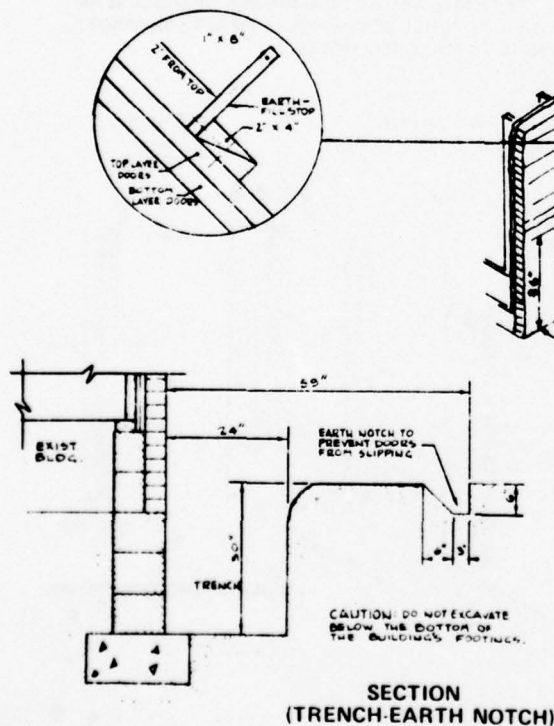
EXCAVATE TRENCH AND EARTH NOTCH. PLACE EXCAVATED EARTH OUTSIDE SHELTER LIMITS FOR LATER USE.

STEP 3

REMOVE DOOR KNOBS FROM ALL DOORS. PLACE DOUBLE LAYER OF DOORS IN NOTCH AND AGAINST WALL AS SHOWN IN SKETCH. EARTH-FILL STOP CAN BE NAILED TO TOP LAYER DOORS BEFORE OR AFTER PLACEMENT OVER TRENCH BY USING ABOUT 10 NAILS PER DOOR WIDTH. PLACE ONE DOOR ON EDGE LENGTHWISE AS THE END CLOSURE.

STEP 4

PLACE ONE END OF THE WATERPROOFING MATERIAL UNDER THE TOP EDGE OF THE DOORS BEFORE EARTH FILL IS PLACED. BEGIN PLACEMENT OF EARTH FILL ON DOORS. COVER THE EARTH FILL WITH WATERPROOFING MATERIAL, SECURING IT WITH A THIN LAYER OF EARTH TO PREVENT IT FROM BLOWING AWAY.



STEP 5

CONSTRUCT ENTRANCE - FILL "SANDBAG PILLOW CASES" WITH EARTH TAKEN FROM THE TRENCH AND STACK TO DIMENSIONS SHOWN AFTER DOORS ARE IN PLACE. PLASTIC OR POLYETHYLENE (WATERPROOFING MATERIAL) ENTRANCE COVER SHOULD BE IN PLACE BEFORE EARTH FILL IS PUT ON THE DOORS.

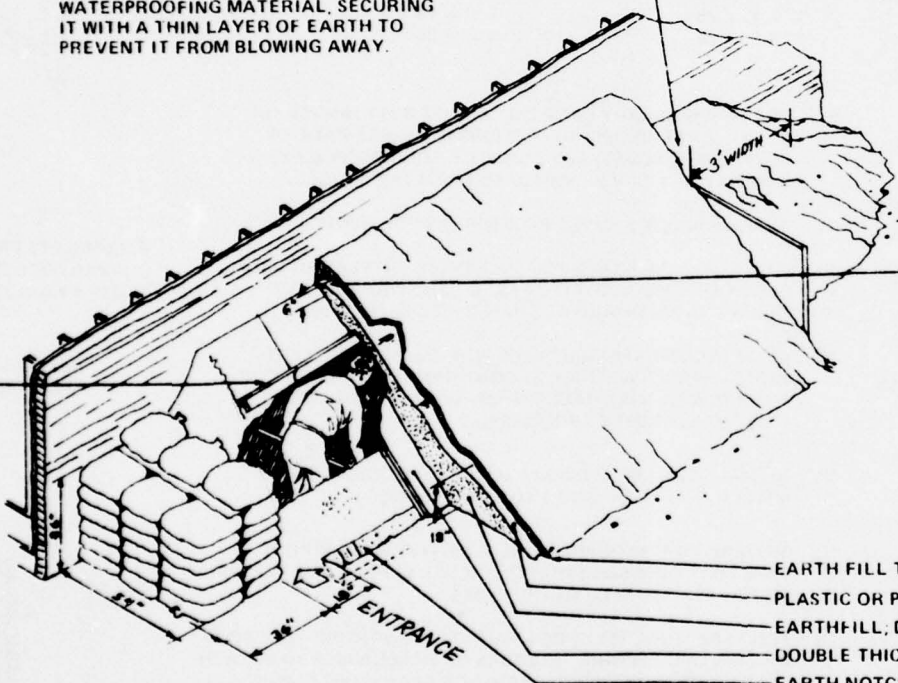
GRADIENT FALLOUT SHELTER DOORS AND EARTH

WIDTHS, AS DIMENSIONED ON THE SECTION
DETERMINE THE LENGTH OF TRENCH AND
PER PERSON TO BE SHELTERED.

PLACE
MITS

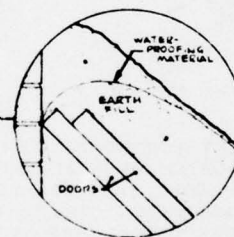
STEP 4

PLACE ONE END OF THE WATERPROOFING MATERIAL UNDER THE TOP EDGE OF THE DOORS BEFORE EARTH FILL IS PLACED. BEGIN PLACEMENT OF EARTH FILL ON DOORS. COVER THE EARTH FILL WITH WATERPROOFING MATERIAL, SECURING IT WITH A THIN LAYER OF EARTH TO PREVENT IT FROM BLOWING AWAY.



TOOLS AND MATERIALS

1. TOOLS: PICK, SHOVEL, HAMMER, SAW, SCREWDRIVER, KNIFE, YARDSTICK.
2. SANDBAGS OR PILLOWCASES - AT LEAST 39.
3. LUMBER: 1" X 8" PIECES AND 2" X 4" PIECES FOR EARTH-FILL STOP. TOTAL LENGTH EQUAL TO LENGTH OF SHELTER.
4. ROPE OR CORD TO TIE SAND BAGS.
5. DOORS: TWO LAYERS FOR LENGTH OF SHELTER PLUS ONE FOR END CLOSURE.
6. NAILS: 8 penny (2 1/2" LONG), ABOUT 10 PER WIDTH OF DOUBLE LAYER DOORS.
7. PLASTIC OR POLYETHYLENE (WATERPROOFING MATERIAL) TO COVER DOUBLE LAYER OF DOORS PLUS ENTRANCE.
8. WORK GLOVES FOR EACH WORKER.



- EARTH FILL TO SECURE WATERPROOFING MATERIAL
- PLASTIC OR POLYETHYLENE WATERPROOFING MATERIAL
- EARTH-FILL, DEPTH - 6 INCHES AT TOP, 12 INCHES AT BASE
- DOUBLE THICKNESS OF DOORS
- EARTH NOTCH TO KEEP DOORS IN PLACE

STEP 5

CONSTRUCT ENTRANCE - FILL "SANDBAG PILLOWCASES" WITH EARTH TAKEN FROM THE TRENCH AND STACK TO DIMENSIONS SHOWN AFTER DOORS ARE IN PLACE. PLASTIC OR POLYETHYLENE (WATERPROOFING MATERIAL) ENTRANCE COVER SHOULD BE IN PLACE BEFORE EARTH FILL IS PUT ON THE DOORS.

GENERAL INFORMATION

READ AND STUDY ALL INSTRUCTIONS BEFORE STARTING TO BUILD. THE LOCATION SELECTED FOR THIS SHELTER SHOULD BE LEVEL OR GENTLY SLOPING DOWN AND AWAY FROM THE MASONRY WALL. A FOUR-PERSON SHELTER CAN BE CONSTRUCTED BY FOUR PEOPLE WORKING A TOTAL OF 12 HOURS EACH

DO NOT EXCAVATE
BOTTOM OF
TRENCH FOOTING.

TION
ARTH NOTCH)

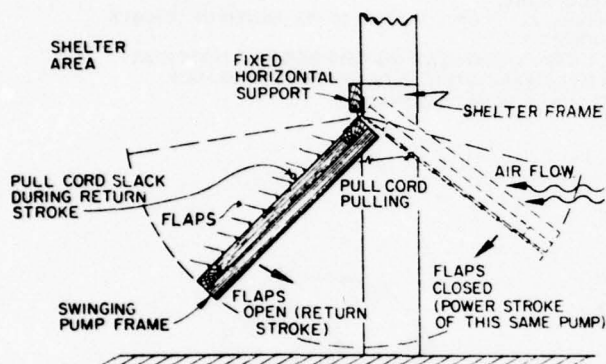
EXPEDIENT FALLOUT SHELTER

AIR VENTILATION PUMP—EMERGENCY LAMP

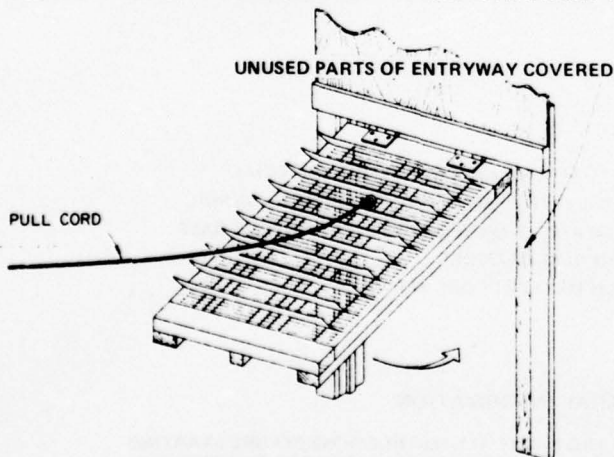
ALL EXPEDIENT SHELTERS ARE DESIGNED TO PROVIDE FOR SOME NATURAL VENTILATION. IN VERY HOT WEATHER, ADDITIONAL VENTILATION MAY BE REQUIRED TO PROVIDE A LIVABLE TEMPERATURE. CONSTRUCTION OF AN AIR PUMP THAT CAN PROVIDE ADDITIONAL VENTILATION IS ILLUSTRATED BELOW.

STUDY ALL INSTRUCTIONS BEFORE
STARTING CONSTRUCTION

STEP 1 AIR PUMP



THE AIR PUMP OPERATES BY BEING SWUNG LIKE A PENDULUM. IT IS HINGED AT THE TOP OF ITS SWINGING FRAME. IT IS SWUNG BY PULLING AN ATTACHED CORD. THE FLAPS ARE FREE TO ALSO SWING AND WHEN THEY ARE IN THE CLOSED POSITION, AIR IS PUSHED THROUGH THE OPENING THAT THE PUMP IS ATTACHED TO.



TO OBTAIN MAXIMUM EFFICIENCY AND MOVE THE LARGEST AMOUNT OF AIR, THE UNUSED PORTIONS OF THE ENTRYWAY SHOULD BE COVERED WITH WOOD, PLASTIC, CLOTH, STIFF PAPER OR SIMILAR MATERIALS.

STEP 2 MATERIALS AND TOOLS NEEDED TO CONSTRUCT AN AIR PUMP

(MATERIALS SIZED FOR A 36-INCH BY 29-INCH PUMP)
LUMBER SIZES CAN BE ALTERED, DEPENDING ON AVAILABILITY.

* A. LUMBER

SIZE	QUANTITY	SIZE	QUANTITY
1" X 2" X 36"	2	1" X 2" X 32"	2
1" X 1" X 36"	1	1" X 1" X 32"	1
1" X 2" X 29"	2	1" X 4" X 36"	1

B. ONE PAIR ORDINARY DOOR OR CABINET BUTT HINGES, OR METAL STRAP HINGES, OR IMPROVISED HINGES MADE OF LEATHER, WOVEN STRAPS, CORDS OR FOUR HOOK & EYE SCREWS WHICH CAN BE JOINED TO FORM TWO HINGES.

C. 24 NAILS ABOUT 2" LONG, PLUS SCREWS FOR HINGES.

*D. POLYETHYLENE FILM, 3 TO 4 MILS THICK, OR PLASTIC DROP-CLOTH, OR RAINCOAT-TYPE FABRIC, OR STRONG HEAVY PAPER — 10 RECTANGULAR-SHAPED PIECES, 30" X 5 1/2".

*E. 30' OF SMOOTH, STRAIGHT WIRE FOR USE AS FLAP PIVOT WIRES — (ABOUT AS THICK AS COAT-HANGER WIRE) OR CUT FROM 10 WIRE COAT HANGERS, OR 35' OF NYLON STRING (COAT-HANGER WIRE THICKNESS).

*F. 30 SMALL STAPLES, OR SMALL NAILS, OR 60 TACKS TO ATTACH FLAP PIVOT WIRES TO WOOD FRAME.

*G. 30' OF 1/4" TO 1" WIDE PRESSURE-SENSITIVE WATERPROOF TAPE THAT DOES NOT STRETCH, OR USE NEEDLE AND THREAD TO SEW HEM TUNNELS TO THE FLAPS.

*H. FOR FLAP STOPS, 150 FT OF LIGHT STRING, STRONG THREAD, OR THIN SMOOTH WIRE. 90 TACKS OR SMALL NAILS TO ATTACH FLAP STOPS TO THE WOOD FRAME, OR FLAP STOPS CAN BE TIED TO THE FRAME.

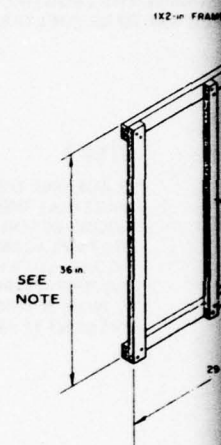
I. 10 FEET OF CORD FOR THE PULL CORD.

J. DESIRABLE TOOLS: HAMMER, SAW, WIRECUTTER-PLIERS, SCREWDRIVER, SMALL DRILL, SCISSORS, KNIFE, YARDSTICK, AND PENCIL.

* Items must be sized or adjusted to fit opening into which airpump is to be placed.

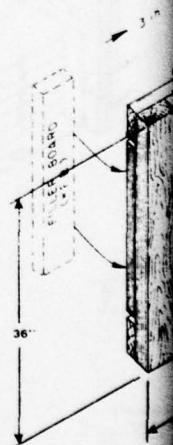
STEP 3 HOW TO

A. CUT LUMBER



B. COMPLETE FRAME AVAILABLE TO USE A NAIL TO M

NOTE HINGES
THE FRONT S



AT FALLOUT SHELTER

PUMP—EMERGENCY LAMP

STEP 3 HOW TO CONSTRUCT THE AIR PUMP

A. CUT LUMBER AND ASSEMBLE FRAME AS SHOWN

STEP 2 MATERIALS AND TOOLS NEEDED TO CONSTRUCT AN AIR PUMP

(MATERIALS SIZED FOR A 36-INCH BY 29-INCH PUMP)
LUMBER SIZES CAN BE ALTERED, DEPENDING ON AVAILABILITY.

* A. LUMBER

SIZE	QUANTITY	SIZE	QUANTITY
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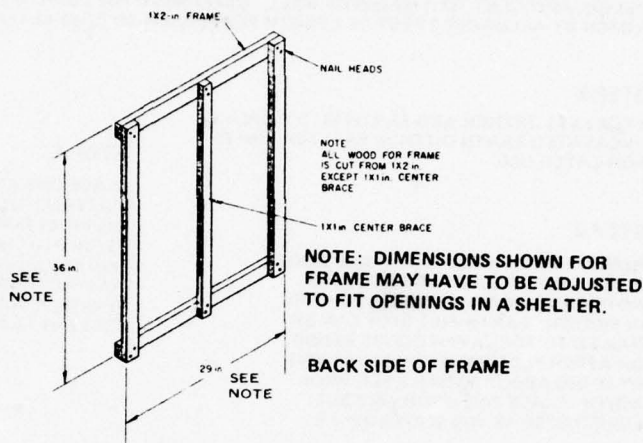
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*H. FOR FLAP STOPS, 150 FT OF LIGHT STRING, STRONG THREAD, OR THIN SMOOTH WIRE. 90 TACKS OR SMALL NAILS TO ATTACH FLAP STOPS TO THE WOOD FRAME, OR FLAP STOPS CAN BE TIED TO THE FRAME.

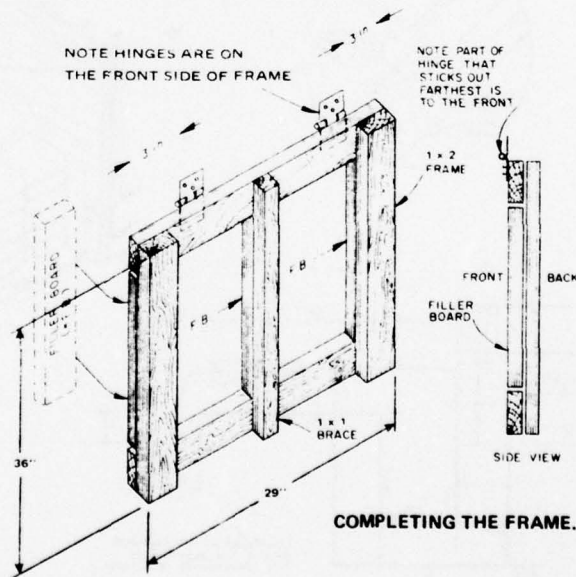
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J. DESIRABLE TOOLS: HAMMER, SAW, WIRECUTTER-PLIERS, SCREWDRIVER, SMALL DRILL, SCISSORS, KNIFE, YARDSTICK, AND PENCIL.

* Items must be sized or adjusted to fit opening into which airpump is to be placed.

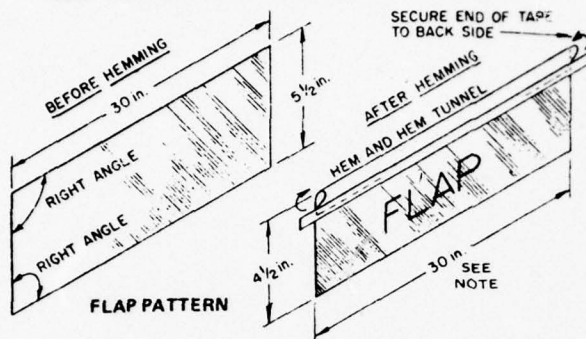


B. COMPLETE FRAME AND ATTACH HINGES. IF DRILL IS NOT AVAILABLE TO DRILL SCREW HOLES TO ATTACH HINGES, USE A NAIL TO MAKE THE HOLES.



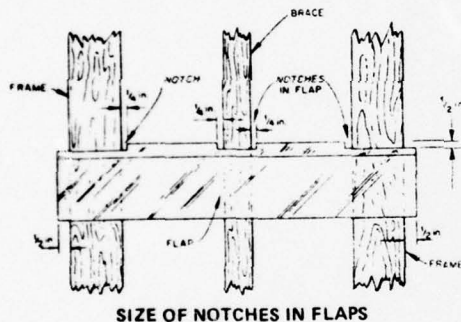
HOW TO CONSTRUCT THE AIR PUMP (CONT'D)

- C. CUT 10 RECTANGULAR STRIPS 30" LONG BY 5 1/2" WIDE FOR USE AS FLAPS. HEM FLAPS AS SHOWN. USE PRESSURE-SENSITIVE TAPE OR SEW HEM SHUT TO FORM HEM TUNNEL.

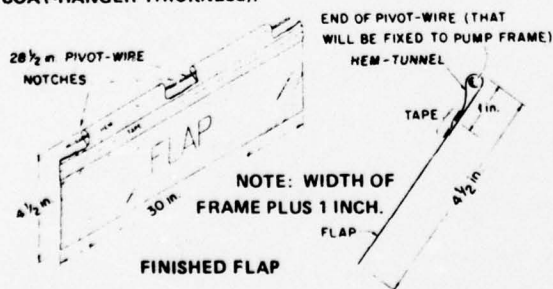


NOTE: WIDTH OF FRAME PLUS 1 INCH

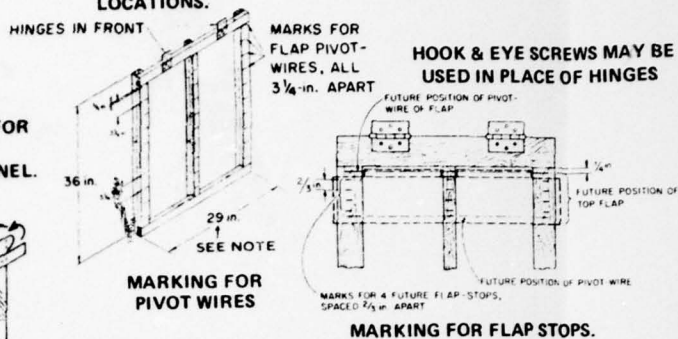
AFTER HEM IS MADE, CUT NOTCHES IN FLAPS AS SHOWN. AVOID CUTTING TAPE THAT HOLDS HEM.



INSERT 10 PIECES OF STRAIGHT WIRE (PIVOT WIRES) INTO FLAP HEM AS SHOWN. FLAPS SHOULD SWING FREELY. STRING CAN BE USED IF WIRE NOT AVAILABLE (WIRE COAT-HANGER THICKNESS).

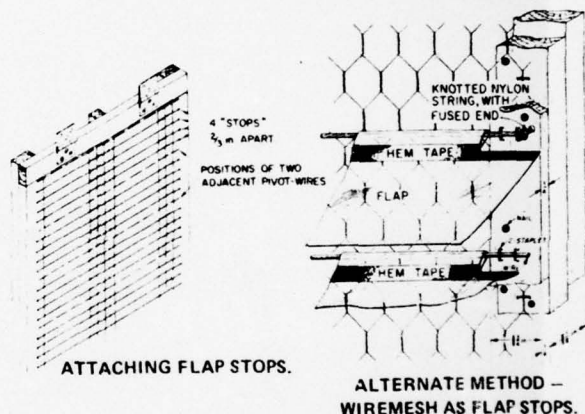


- D. MARK PUMP FRAME FOR PIVOT WIRE AND FLAP STOP LOCATIONS.



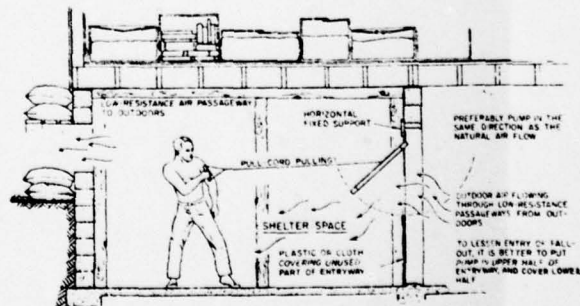
NOTE: FRAME DIMENSIONS MAY HAVE TO BE ADJUSTED TO FIT OPENING IN SHELTER

- E. ATTACH FLAP STOPS (STRINGS OR WIRES) TO THE PUMP FRAME AT THE MARKED LOCATIONS. 4 FLAP STOPS ARE NEEDED BETWEEN ADJACENT PIVOT WIRES



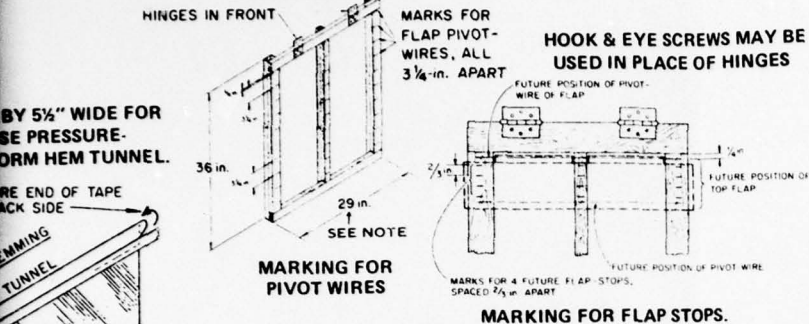
- F. STARTING FROM THE BOTTOM - STAPLE, NAIL, TACK OR TIE THE FLAP PIVOT-WIRES WITH FLAPS IN THEIR MARKED POSITIONS. ATTACH HINGES TO HORIZONTAL SUPPORT BOARD. ATTACH PULLCORD TO CENTER BRACE.

STEP 4. TYPICAL INSTALLATION OF AIR PUMP



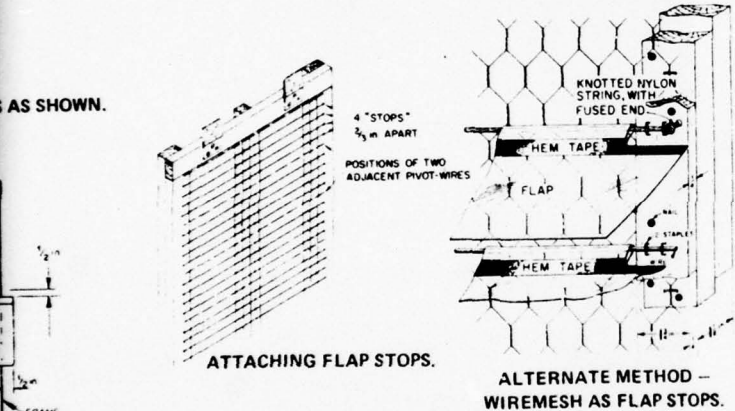
NT'D)

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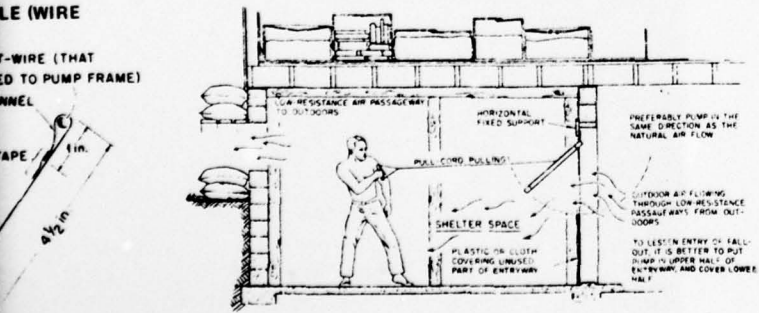
NOTE: FRAME DIMENSIONS MAY HAVE TO BE ADJUSTED TO FIT OPENING IN SHELTER

E. ATTACH FLAP STOPS (STRINGS OR WIRES) TO THE PUMP FRAME AT THE MARKED LOCATIONS. 4 FLAP STOPS ARE NEEDED BETWEEN ADJACENT PIVOT WIRES



F. STARTING FROM THE BOTTOM - STAPLE, NAIL, TACK OR TIE THE FLAP PIVOT-WIRES WITH FLAPS IN THEIR MARKED POSITIONS. ATTACH HINGES TO HORIZONTAL SUPPORT BOARD. ATTACH PULLCORD TO CENTER BRACE.

STEP 4. TYPICAL INSTALLATION OF AIR PUMP



EMERGENCY LAMP

STEP 5. EMERGENCY LAMP

THIS TYPE OF LAMP WILL PROVIDE LIGHT FOR USE IN EXPEDIENT SHELTERS - THE LAMP WILL BURN SLOWLY CONSUMING ABOUT 3 OUNCES OF COOKING OIL IN 24 HOURS.

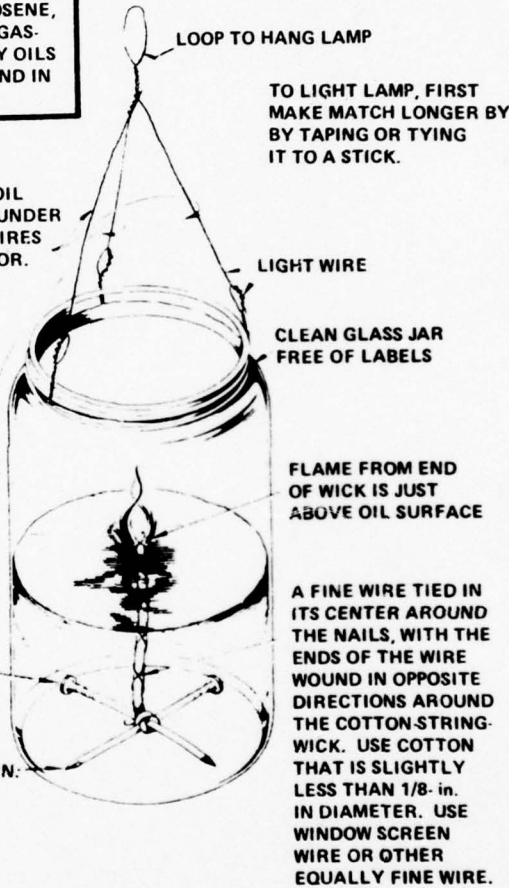
WARNING
DO NOT USE KEROSENE, DIESEL FUEL, OR GASOLINE - USE ONLY OILS OF THE KIND FOUND IN THE KITCHEN.

ATTACH ALUMINUM FOIL 2/3 AROUND JAR AND UNDER ITS BOTTOM AND TO WIRES TO ACT AS A REFLECTOR. (NOT SHOWN.)

FILL JAR NO MORE THAN HALF-FULL WITH COOKING OIL

BENT NAIL, TIED OVER TOP OF ANOTHER BENT NAIL, SO THE BASE WILL NOT ROCK.

USE NAILS ABOUT 1/2-IN. SHORTER THAN THE DIAMETER OF JAR



KEEP EXTRA WIRE AND WICK-STRING IN SHELTER.

FEASIBILITY OF CITIZEN CONSTRUCTION
OF EXPEDIENT FALLOUT SHELTERS

Spencer J. Condie* Reese J. Goodwin[†] John F. A. Seggar*

ABSTRACT

Seventeen different families or groups of individuals untrained in building techniques constructed one of the following seven alternative expedient fallout shelters: Door-Covered Trench, Log-Covered Trench, Car-Over-Trench, Aboveground Door-Covered, Crib-Walled, Ridge-Pole, and Tilt-up Doors and Earth.

The builders of each shelter were guided only by one-page instructions prepared for that shelter by Defense Civil Preparedness Agency. Nine of these same families or groups also built an expedient shelter-ventilating pump, following brief instructions of Defense Civil Preparedness Agency.

To simulate crisis conditions, the groups were offered a base pay rate for constructing each respective shelter within a specified time frame. If the shelter were completed in half the specified time, an additional bonus was given. With the exception of only one group, all participants received the bonus.

Generally speaking, the participants demonstrated that construction of the respective shelters in accordance with the shelter designs was feasible. The builders were less successful in following the brief instructions for making an expedient air pump. Of the nine pumps built, only four would pump air effectively.

Numerous suggestions were made by the participants and observers regarding the improvement of the instructions. Among the more general suggestions were: (1) instructions should not be condensed to only one page; (2) brief explanations should be given regarding why certain steps are taken; (3) selection criteria for locating a shelter site should be suggested; (4) more illustrations which are less complex should be included in each set of plans.

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1. INTRODUCTION

There is growing need for a defense posture that will complement our nation's ever increasing offensive technology in the nuclear arms race. A number of alternative "expedient" shelter plans have been developed. If shelters are properly constructed in accordance with these plans, they would provide considerable protection in the event of a nuclear attack.

The seven alternative high-protection-factor expedient shelters covered by this report were each built by a family or group using a one-page instruction sheet prepared and supplied by the Defense Civil Preparedness Agency. Six of these seven types of shelters already had undergone field testing to determine if untrained American families have the ability to construct them while guided only by written instructions. These prior experiments are described in an Oak Ridge National Laboratory report.¹ However, the families that built the shelters described in this and several other ORNL reports were each guided by detailed, step-by-step, illustrated instructions - much longer and more detailed than the one-page instructions used in the Brigham Young University field tests.

Three of the designs involve the digging and covering of trenches and are referred to, respectively, as (1) the Door-Covered Trench Shelter, (2) the Log-Covered Trench Shelter, and (3) the Car-Over-Trench Shelter. Four additional shelters are designed for use in areas which either have very high water tables or extremely rocky or unstable soil which prohibits or impairs the use of deep trenches. These four designs are: (1) the Aboveground Door-Covered Shelter, (2) the Crib-Walled Shelter, (3) the Ridge-Pole Shelter, and (4) the Tilt-up Doors and Earth Shelter.

The use of some shelters assumes that a large number of small trees are available for making poles. Another shelter is appropriate for construction in an area in which buildings or other walls are available. Still other shelters are adaptable to small-family utilization, whereas others are constructed for multiple-family habitation.

A crucial element in the construction of any expedient structure is the provision of air circulation, given the crowded quarters and high

humidity. Therefore, the construction of shelters also involved the construction of an expedient air pump which facilitated adequate air circulation within the shelter.

This research evaluated the ability of the "average," unskilled family's ability to follow cursory instructions in constructing an expedient nuclear fallout shelter under simulated stress conditions and time constraints. We were concerned with addressing the following research questions:

1. Is the population generally functionally literate enough to comprehend brief instructions so the shelter is properly constructed, congruent with the printed shelter plans?
2. Given adequate literacy and comprehension, are citizens who are unskilled in building construction facile enough to faithfully execute the construction of the given shelters so they are safe and habitable?
3. Does the typical American household have ready access to rudimentary tools necessary for the construction of an expedient shelter, for example, shovels, hammers, saws, hatchets, etc.?
4. Given the occasional lack of optimal tools and construction material, are typical citizens innovative enough to substitute or create tools and materials which adequately meet the building requirements of a given shelter?
5. Given simulated emergency conditions, can families adequately mobilize their energies and resources and develop a division of labor which will effectively attain the objective of building a specified, secure shelter?

To facilitate the evaluation of the citizen construction of the seven different expedient shelters, 17 different groups were invited to participate in the construction of one of the following respective shelters (Table 1).

The most important shelters (Door-Covered Trench and Log-Covered Trench) were experimentally constructed, respectively, by four and three different groups, with the remaining five shelters being constructed by two groups each. In order to simulate crisis conditions, the groups

Table 1. Number and type of expedient shelters constructed

Shelter design	No of shelters built	Base time (hr)	Bonus time (hr)	Person capacity
Door-Covered Trench	4	72	36	6
Log-Covered Trench	3	72	36	6
Car-Over-Trench	2	72	36	3
Aboveground Door-Covered	2	72	36	6
Crib-Walled	2	96	48	6
Ridge-Pole	2	96	48	15
Tilt-up Doors and Earth	2	72	36	6

were given variation in payment. If the expedient shelter was properly constructed within the "base time" cited above, they were renumarated at the rate of pay prescribed in Appendix A. However, if the shelter was properly constructed within half the allocated base time, a bonus was awarded to each group. The strong inducement to achieve the given objective within half the allocated time simulated the time constraints associated with an alert preceding a nuclear attack.

REFERENCE FOR SECTION 1

1. Cresson H. Kearny, *Expedient Shelter Construction and Occupancy Experiments*, ORNL-5039 (March 1976).

2. DEMOGRAPHIC CHARACTERISTICS OF SHELTER CONSTRUCTION PARTICIPANTS

Individuals in the sample were identified and contacted approximately two weeks prior to the actual construction of the shelter. Seventeen different groups participated in the construction of the seven shelter designs discussed previously. This sample size obviously precluded the use of random sampling techniques. Therefore, we relied upon a purposive sample of families and individuals within Utah County who represented diverse socioeconomic, educational, ethnic, and religious backgrounds.

Utah County has a population of approximately 125,000 residents, of whom approximately 75% are members of The Church of Jesus Christ of Latter-Day Saints (Mormon). Less than 1% of the population is nonwhite. In order to more closely approximate the religious and ethnic population of the United States, we disproportionately overselected non-Mormons and nonwhites in our sample (Table 2).

To further approximate varying group configurations throughout the United States, we selected two groups of unmarried females, one group consisting of a divorced mother with children, one married couple who worked with another family of three, three married couples without children, and ten other families ranging in size from three to eight members.

Of the 17 groups, one was Maori, one American Indian, and yet another consisted of two single Anglo and Mexican men. Six Mexican or Chicano families were invited to participate in the project. All but one of these families declined the initial invitations; however, this family later refused to participate upon receiving the shelter designs and final instructions.

Eleven of the groups were Mormon, two groups were Lutheran, two were Protestant, one was Catholic, and one was Methodist. Only very general parameters of the task were explained; the participants had no knowledge of the specific shelter design or location of the construction site prior to the actual notification on the day they received instructions.

A contractual agreement was signed (Appendix B) by all participants after very detailed instructions were given regarding the expectations of the granting agency, the base pay, stipulations for bonuses, and the reimbursement for any building material not provided by the researchers.

Table 2. Demographic characteristics of shelter construction participants

Group No.	Group status	Ethnicity	Religious preference	Group size	Shelter design
1	Family	Anglo	Mormon	6	Door-Covered Trench
2	Family	Anglo	Lutheran	3	Aboveground Door-Covered
3	Married couple	Anglo	Lutheran	2	Aboveground Door-Covered
4	Family	Anglo	Mormon	3	Door-Covered Trench
5	Family	Anglo	Mormon	8	Log-Covered Trench
6	Family	Maori-Anglo	Mormon	5	Door-Covered Trench
7	Single males	Anglo-Mexican	Mormon	2	Door-Covered Trench
8	Single females	Anglo	Mormon	2	Log-Covered Trench
9	Single females	Anglo	Protestant	2	Tilt-up Doors and Earth
10	Family	Anglo	Mormon	7	Ridge-Pole
11	Family	Anglo	Methodist	4	Crib-Walled
12	Married couple	Anglo	Mormon	2	Car-Over-Trench
13	Family	Indian	Mormon	5	Car-Over-Trench
14	Family	Anglo	Catholic	4	Log-Covered Trench
15	Mother and children	Anglo	Protestant	5	Tilt-up Doors and Earth
16	Family	Anglo	Mormon	6	Ridge-Pole
17	2 married couples	Anglo	Mormon	5	Crib-Walled

The evaluation team provided hollow-core doors for the designs requiring such doors. Poles were also provided where needed to avoid the conservation problems of destroying timber near national forests. Participants were required to cut the poles to the proper size, however. In the one design involving a Car-Over-Trench Shelter, an old-model car was provided.

During the evaluation of the building process, trained, advanced student observers kept detailed notes of their observations of the interpersonal communication of instruction, etc. An engineering graduate student and a professor also periodically observed the construction of the shelters to determine their structural adequacy and the degree to which the shelter construction followed the design.

The observers were given strict instruction not to give any verbal or written assistance to the families during the fabrication of the shelters.

After the construction of the respective shelter, each participant underwent a debriefing interview which determined: (1) any communication ambiguities in the instructions; (2) problems encountered in motivating group members to participate in the construction; (3) reactions to the stress involved in hurriedly constructing the shelter in the face of self-imposed and externally imposed deadlines; and (4) suggestions for the enhancement of the design, that is, any innovative or creative ideas.

Immediately after the completion of the shelters, most participants were so exhausted that their attention was focused upon their own physical condition. Therefore, detailed debriefings were generally conducted after the participants had had a few days to think about their experience.

We found this waiting period to be very productive, especially when the participants returned to the shelter site and recalled problems and areas of concern raised during the construction process. Their reactions then became a reliability check for the field notes of the observers.

3. LOCATION OF CONSTRUCTION SITE

All 17 shelters were constructed on a 20-acre tract of land in Hobble Creek Canyon, located 20 miles southeast of Provo, Utah. This location proved to be optimal for a number of reasons. First, it is very secluded, with the last mile leading to the site consisting of a private dirt road. This seclusion permitted considerable security and privacy. It was possible to stockpile hollow-core doors, logs, plastic sheets, and other materials without special security precautions.

Second, the terrain was diversified, with steep mountains on either side of a fairly flat, little valley. A streambed ran through the flat land. Some terrain was rocky and conducive to the construction of above-ground shelters, whereas the soil close to the small stream was much more conducive to shelters involving trenches.

Located on this same site was a 30-ft mobile home which had been placed upon a permanent foundation. This foundation ranged from approximately 3 to 5 ft above the ground and provided an excellent wall for the construction of the two Tilt-up Doors and Earth Shelters.

All participants were allowed to select their own shelter sites within the perimeter of this particular tract of land. Some, who sought to avoid the rockier ground near the base of the mountains, selected locations under some large trees near the streambed. They later learned that digging trenches through 2-in. roots was as difficult as digging in rocky soil.

All 17 shelters were constructed between June 3, 1977, and July 31, 1977, primarily on weekends. Thus, on occasion two shelters would be simultaneously under construction on the same large site. To prevent participants from conferring with or imitating each other, they were given either (1) different shelter designs whenever two or more groups were constructing shelters on the same weekend, or (2) they were located far enough apart that they could not see each other through the vegetation. Numerous photographs were taken of each respective shelter at various stages of construction. Upon completion, the shelters were either dismantled or covered with opaque plastic sheets so that other participants would not arrive on the site and be able to see a completed model of the shelter they were required to construct.

4. FINDINGS

Work mode. Participants devised their own unique solutions to division of labor. No suggestions were given in this regard, but various kinds of solutions will be discussed in the next section.

Although a number of problems were encountered in understanding the printed shelter plans, in nearly all cases, areas of misunderstanding were such that, upon the builders conferring with each other, they were led to an optimal solution. Thus, there were some slight departures from the printed shelter designs, but these were, in most cases, minor and did not impair the overall protection factor or safety of the shelter.

Only one group failed to meet the minimum specifications of their shelter design, and their participation was terminated when the car used in the Car-Over-Trench Shelter fell partly into the trench. All other participants were able to complete even the most complex shelters.

Suggestions for improving instructions. Following the discussion of each respective shelter will be a detailed list of suggestions for improving instructions. These represent a synthesis of observations by the civil engineer, the sociologist who conducted the debriefing interviews, and the observers. In the debriefing, the participants were invited to be very critical and candid about the printed shelter designs. Some of the suggestions may appear to be somewhat picayune; however, the frequency with which various problems occurred will be indicated in the tables in each section and will help to indicate which suggestions for improvement should be given the greatest credence.

4.1 Door-Covered Trench Shelter

Group composition. Group 1 consisted of a 29-year-old father, a 24-year-old mother, and four children, ages 8 months and 2, 4, and 5 years. The father and mother performed all the labor, with the mother occasionally attending to the needs of the children while her husband dug the trench.

Group 2 was composed of a 23-year-old father, a 22-year-old mother, and an 8-month-old baby. The mother's only contribution to the construction of the shelter consisted primarily in holding the measuring tape for her husband. Otherwise, the husband performed most of the labor.

Group 3 included two young bachelors, a 22-year-old Anglo and a 17-year-old Mexican who had lived in the U.S. for eight months. Both shared the work equally, and the young Mexican could speak English sufficiently well to understand the construction plans.

Group 4 was a Maori family who had come to the United States from New Zealand. Both father and mother were 30 years old, and they had three children, ages 9 months and 2 and 3 years. Although the mother was five months pregnant, she shared a good portion of even the heavy construction work with her husband.

Communication-construction problems. The Door-Covered Trench design was the first to be constructed (see Table 3 for list of materials). At the time, the only construction plans available had been reduced to one 8-1/2 x 11 in. sheet of paper. Thus a common complaint of at least two of the first participating groups was that the instructions were barely legible. A few days later we received enlarged shelter plans which mitigated that problem in the construction of the other designs.

Through a miscommunication among the research staff, groups 1 and 2 were given the instructions 10 hr prior to the commencement of construction. These two families also spent less time than did others in consulting the plans at the construction site. However, despite the advance notice, the second family had several problems and areas of misunderstanding and uncertainty while constructing the shelter.

As indicated by Table 4, two of the four groups suggested a need for more illustrations to be included in the plans. The whole concept of a nuclear shelter was so foreign to them they had difficulty conceptualizing the construction of entrances, the entrance steps, and ventilation trenches. One group was very uncertain about how to construct a drainage trench, a canopy, and how to build earth rolls on top.

An additional problem encountered on this design (and many of those which follow) was uncertainty on the part of two groups regarding the depth of dirt on the trench top. A brief and simple explanation of the principle of earth arching and the protection that earth affords against both a nuclear blast and radioactive fallout ought to be included in the plans.

Table 3. Materials used in construction of
Door-Covered Trench Shelters

	Group No.			
	1	2	3	4
Group size	6	3	2	5
Workers	2	2	2	2
Nonworkers	4	1	0	3
Tools and materials				
Shovels	2	1	2	1
Axes	1	1	0	1
Picks	1	1	0	1
Hammers	0	0	0	0
Saws	0	0	0	1
Nails	0	0	0	* ^a
Knives	1	1	1	0
Lantern	1	0	0	0
Measuring tape (ruler or yardstick)	1	1	1	1
Gloves (pairs)	2	1	2	1
String or rope	*	*	*	*
Sheets	6	2	2	0
Pillowcases	6	4	6	2
Plastic covering	0	0	0	*
Doors	0	0	0	3
Materials supplied				
Doors	3	3	3	0 ^b
Plastic covering	1	1	1	1
No. times design consulted	12	24	22	25
Length of time consulted, min	50	100	116	120
Actual construction time, hr	17	11.9	9.8	12
Total time involved, hr	29	32	10.7	14

^aDesignates use of, rather than a specified number of
nails, ropes, etc.

^bSupplied own doors.

Feasibility of construction. Our observations conclusively indicate that individuals and groups unskilled in construction have the capability of following rudimentary construction plans in building this expedient shelter. In some cases, trial and error seemed to be a necessary step toward optimal completion. Although a number of areas of uncertainty were

Table 4. Problems in communication and construction encountered by four groups constructing the Door-Covered Trench Shelters

Specific problems	Groups encountering problem			
	1	2	3	4
Plans were too small to be read clearly	X		X	
Need more illustrations	X		X	
Specified width of entrance is unclear		X	X	
Uncertain how to construct entrance steps		X	X	
Uncertain how to build earth rolls on top		X		
Uncertain how to make ventilation trench		X		X
Uncertain how to construct drainage trench			X	
Uncertain how to construct canopy			X	
Uncertain regarding depth of dirt on trench top		X		X

encountered, all four groups were able to construct satisfactory shelters within a 36-hr period (see Fig. 4.1).

Suggestions for improvements

1. The illustrations for the ventilation trench and entrance need to be more explicit, including precise measurement figures and perhaps illustrations from different angles.

2. Groups sometimes covered the trench in such a way as to defeat the principle of earth arching. A brief explanation of the necessity for earth arching might be included so they will know why a particular depth of earth must be maintained.



Fig. 4.1. Canopies neatly erected over Door-Covered Trench Shelter entrances. Winds and rainwater later knocked them down.

3. The instructions say the earth should be "about 12 inches deep." This is misleading inasmuch as some groups considered 9 or 10 in. to be "about" 1 ft. This depth may be dangerously insufficient. The wording could include: "the earth should be at least one foot in depth."

4. In some instances the doors began cracking when the heavy earth was placed first in the center. A note should be included to suggest covering the doors around the periphery first and gradually heaping the dirt into the middle, since the earth arching relieves some of the strain on the center of the trench door covers.

5. In most instances the plastic used for the canopies and earth rolls was black and may be melted by a thermal pulse. White or translucent plastic may be suggested as a preferable alternative.

6. The printed plans need to be large enough to be clearly legible.
7. At various junctures all four groups were confused by the complex illustrations. For those who are inexperienced in reading blueprints and three-dimensional drawings with cutouts, it may be well to have an illustration of every two or three steps from both the top and the side view. The written instructions can remain brief if more illustrations are included. A suggested sequence of steps and illustrations is shown in Appendix C.
8. The construction steps need to be laid out in a logical sequence rather than scattered throughout the whole page.
9. The instructions are now crammed onto one page. Two pages with larger print and a more fully illustrated set of instructions would be easier to understand.
10. The instructions need to suggest an ax in case roots must be cut and stakes made.
11. The statement "2 pillowcases per person" needs to be restated as "a minimum of 6 pillowcases regardless of the number of participants."
12. Some groups thought it was illogical when building the roof to have a layer of earth, then a layer of plastic, then another layer of earth. They thought the plastic ought to be the first layer. Although they followed the instructions, in an actual attack they might do what appears to be the most logical. Therefore, an explanation needs to be made regarding the purpose for the plastic being in the center.
13. Perhaps a top-view illustration needs to be included of the drainage trench. Several thought it should be only on the sides instead of all the way around.
14. According to the illustration, the construction of the canopy results in holes being poked in the plastic where it meets the support poles. An illustration needs to show how it can be constructed without being perforated.
15. Specifications are needed for the dimensions of the canopy, especially for the height of the canopy at the sides and the center.
16. Specify that 100 ft of string or rope is needed and that rope or heavy cord is preferable to string in securing the canopies.

17. Specify that wood suitable for making stakes is necessary.
18. A top-view diagram of the shelter before the dirt is added would be helpful (see Appendix C).

4.2 Log-Covered Trench Shelter

Group composition. The first group consisted of a young family of four with a 29-year-old father, a 31-year-old mother, a boy of 7, and a girl of 6. The contribution of the children was primarily limited to filling sandbags; however, both parents more or less shared the rest of the work equally.

Group 2 was a large family with a father (age 35), mother (age 29), and six children ranging in age from one year to nine years old. This particular family had a rather remarkable division of labor, with the four older children making a significant contribution in the digging of the trench, the youngest laborer being a five-year-old boy. Through a misreading of instructions, the final length of their shelter was a more-than-adequate 22 ft long.

Group 3 consisted of two single women, both of whom were 20 years of age. Both were college coeds who were not particularly athletically inclined and were rather slightly built. The construction task proved to be extremely taxing for them, with completion occurring less than half an hour before the 36-hr deadline for the bonus.

Communication-construction problems. A list of materials used in constructing this shelter is given in Table 5. As indicated by the data in Table 6, this particular shelter design elicited several problems unique to each of the three groups. The greatest concern shared by all three groups, however, was the ambiguity in the instructions regarding the construction of the mudsill. All those concerned sought more specification regarding how far apart the mudsills should be placed and how far they should extend.

The second most frequent complaint dealt with the illegibility of the plans. Again, this design was constructed using plans reduced to an $8\frac{1}{2} \times 11$ in. sheet of paper. The third group received plans on an 11×14 in. piece of paper and voiced far fewer complaints.

Table 5. Materials used in construction of
Log-Covered Trench Shelters

	Group No.		
	1	2	3
Group size	4	8	2
Workers	2	2	2
Nonworkers	2	6	0
Tools and materials			
Shovels	2	3	3
Axes	1	1	0
Picks	0	1	1
Hammers	1	1	0
Saws	0	2	1
Nails	0	0	0
Knives	0	1	0
Lanterns	0	2	0
Crow bar	1	1	0
Rakes	0	0	2
Hoes	0	0	1
Measuring tape (rulers or yardstick)	1	1	2
Gloves (pairs)	1	2	0
String or rope	* ^a	*	*
Sheets	0	8	0
Pillowcases	0	8	0
Materials supplied			
Poles	*	*	*
Plastic covering	*	*	*
Stakes	*	*	*
No times design consulted	19	20	20
Length of time consulted, min	77	120	85
Actual construction time, hr	15.7	20.75	22.5
Total time involved, hr	31.6	35	35.5

^aDesignates use rather than a specified number.

Table 6. Problems in communication and construction encountered by three groups constructing the Log-Covered Trench Shelters

Specific problems	Groups encountering problem		
	1	2	3
Poorly printed plans	X	X	
Uncertain how to construct mudsills	X	X	X
Uncertain whether to put logs or sandbags around vent	X		
Uncertain about placement of 7-ft poles	X		
Difficulty in tying second log to 7-ft pole			
Uncertain how many sandbags must be filled		X	
Uncertain regarding depth of entrance		X	
Newspapers were not strong enough to hold dirt out of large gaps between roof poles		X	
Uncertain whether roof must be rounded		X	
Canopy illustration was inadequate		X	
Did not understand "notched and toe-nailed"			X
Uncertain how to construct ventilation trench			X

All other problems encountered were unique to each group and included: Uncertainty regarding whether to put logs or sandbags around the vent, placement of the 7-ft poles, difficulty in tying a second log to a 7-ft pole, uncertainty regarding how many sandbags must be filled, and ambiguity regarding whether the roof must be rounded. Additional areas of uncertainty were concerned with how deep the entrance should be, how the ventilation trench should be made, a lack of understanding of what "notched and toenailed" indicates, problems with newspapers not keeping dirt out of the gaps between roof logs, and, finally, unclear canopy instructions.

Feasibility of construction. Given the great diversity in group configurations, ranging from two slightly built young women to a family of eight, we feel quite assured that the construction of this particular shelter lies within the grasp of nearly any family. This shelter assumes the ready availability of timber for logs and also fairly loamy and stable soil free from excessive rocks, etc.

In the debriefing session after the shelter had been completed, the father of the large family, who had encouraged and instructed even his five-year-old how to work, exclaimed in pride: "Now I have a feeling of security. I had heard of families making a shelter (an expedient shelter), but didn't know if I could do it. Now I know we can."

The two young women were somewhat less ecstatic upon completion of their shelter. After working for over 22 hr during a 36 hr period, one of them remarked: "If I'd known the work was this hard I would not have agreed to work on a shelter." Nevertheless, she and her compatriot did successfully complete the Log-Covered Trench Shelter and demonstrated that even those of somewhat fragile body build and no building experience can construct this particular shelter within severe time constraints (see Figs. 4.2 through 4.15).



Fig. 4.2. Two young, single women digging the trench for a Log-Covered Trench Shelter.



Fig. 4.3. Interior of Log-Covered Trench Shelter. (Note the large tree root system through which the trench was dug.)



Fig. 4.4. Young women covering logs with newspapers prior to shoveling dirt into log-covered trench.



Fig. 4.5. Completed 4-person Log-Covered Trench Shelter. Flimsy canopy over entry is evidence of the need for better instructions and illustrations to enable an average American to make a stable canopy of specified height, with specified openings for adequate ventilation.



Fig. 4.6. The second Log-Covered Trench Shelter was constructed by a young family with six children under the age of 10. The children 5 and older helped in the construction. The father of this five-year-old showed him where and how to use a shovel in excavating the trench.



PHOTO 3635-77

Fig. 4.7. All but the two youngest children assisted in the very effective division of labor involved in constructing this shelter. Here two of the older boys, ages 8 and 5, are making their contribution to the family shelter.



Fig. 4.8. The father interpreted the trench instructions as requiring 2 ft 9 in. per person rather than per adult. Thus the final trench was 22 ft long, perhaps longer than necessary for a family with so many small children.



PHOTO 3644-77

Fig. 4.9. In addition to assisting in the trench excavation, the young children also aided greatly in carrying logs to the trench. A pile of logs was provided; however, the participants were required to cut them to the proper length and then drag or carry them to the trench location.

PHOTO 3638-77



Fig. 4.10. Dragging the logs with an expedient yoke was somewhat easier for the children than carrying the heavy logs.



PHOTO 3643-77

Fig. 4.11. The children are fastening the yoke cord to the long pole prior to dragging it to the trench site. These children were very cooperative and seldom complained about the amount of work involved. Their cumulative contribution was by no means insignificant.



Fig. 4.12. Covering the trench with quaking aspen logs. These logs are indigenous to the area but are not as uniform in size nor as straight as lodgepole pine logs found in certain other areas. However, they did prove to be adequate for the task at hand.



Fig. 4.13. Filling sandbags was yet another contribution of the children which allowed their parents time to consult instructions and to perform the heavier and more exacting labor.



Fig. 4.14. Covering the trench. Although this young mother of six was expecting another baby, she was in robust health and contributed a considerable amount of work herself.



Fig. 4.15. The six children admire the nearly completed shelter. The girl in the left foreground belonged to another family working elsewhere on another shelter.

Suggestions for improvements

1. General instructions explaining earth arching and suggesting the location of the shelter would be helpful. For example, although large trees may provide shade, they also become an intensified source of fallout from branches and leaves. Root systems also encumber digging. The total dimensions of the construction site should be included; for example, a 4 x 12 ft shelter may actually require a 10 x 20 ft building site in order to allow for trenches, entrances, and a source of earth for covering the roof.

2. Depending upon the stability of the soil, the trench may need to be wider than 42 in. at the top in order to provide a 42-in. width at the bottom without caving in on the sides.

3. The layout of the instructions should provide a verbal description of each step with the illustration for that step, either following directly or placed immediately opposite the verbal description. Miscellaneous notes should also be subsumed under the instructional steps rather than dispersed throughout the plan.

4. A "stand-up hole" could be part of the trench floor, which is dug about 18 in. deeper to allow adults to stand upright and stretch.

5. Plans should specify that ditches completely circumscribe the entire shelter.

6. Specify that 2 ft 9 in. is needed for each additional adult, but not necessarily for each child. (One family with several small children built a shelter 22 ft long.)

7. Specifications are needed regarding how the canopies should be constructed.

8. The list of needed materials should also include nails.

9. Instructions need to be printed clearly, larger, and in an orderly sequence rather than scattered throughout. Two pages would permit more clarity and the inclusion of illustrations.

10. Instructions need to be more specific concerning the number of sandbags, the depth of the entrances, and the rounding of dirt on the roof.

11. For covering the roof, bed sheets or plastic needs to be suggested as the optimal choice, with newspapers as a second choice.

12. Illustrations are too complex and too few. They would be more readily understood if they could be reduced to a few steps at a time and include many simpler pictures (see example in Appendix C).

13. A more detailed explanation and/or illustration of "notched" or "toenailed" needs to be given for those who are inexperienced in construction.

14. Instructions for constructing mudsills need to specify how far apart they are and how far they should extend.

4.3 Car-Over-Trench Shelter

Group composition. The first group was a young married couple, both of whom were 20 years of age. The wife was in the early stages of pregnancy and did not feel very well. Thus, her contribution was limited to occasional use of the pick with long, intermittent rests.

The second group included an American Indian family with a 23-year-old father, a 22-year-old mother, two children under the age of two, and the 17-year-old brother of the father of the family. The two men did most of the trench digging, while the mother of the family tended the children and filled sandbags.

Communication-construction problems. Although the plans specify a width of 28 in. at the bottom of the trench, the dimensions for the top of the trench were somewhat confusing. The married couple had difficulty in digging straight walls, thus adding to the instability of the edges of the trench. When they drove the car over the trench, it began to collapse on one side so that the rear wheel rested inside the trench.

Despite the inclusion of three separate illustrations, it was still not clear to the native American family that the dirt from the trench should be piled far enough away from the trench to allow 44 in. for the car in addition to 36 in. for the plastic sheet earth fill.

Other minor areas of ambiguity included uncertainty whether the instructions sometimes indicated feet (') or inches ("). This was no problem on the larger set of plans, but was sometimes a difficulty with the reduced plans. Another minor problem was that the car is illustrated both with and without seats having been removed. A list of materials used in constructing this shelter is given in Table 7.

Table 7. Materials used in constructing a
Car-Over-Trench Shelter

	Group No.	
	1	2
Group size	2	5
Workers	2	3
Nonworkers	0	2
Tools and materials		
Shovels	2	1
Axes	1	1
Picks	1	0
Hammers	0	1
Saws	0	0
Nails	0	0
Knives	0	1
Lantern	0	0
Measuring tape (rulers or yardstick)	0	1
Gloves (pairs)	0	1 ^a
String or rope	0	* ^a
Sheets	0	0
Pillowcases	0	0
Plastic covering	0	0
Materials supplied		
Car	1	1
Plastic covering	*	*
No. times design consulted	11	16
Length of time consulted, min	45	57
Actual construction time, hr	10.8	11.3
Total time involved, hr	11.9	13.5

^aDesignates use rather than a specified number.

Table 8. Problems in communication and construction encountered by two groups constructing the Car-Over-Trench Shelter

Problems encountered	Groups encountering problem	
	1	2
Uncertain regarding the width of trench	X	X
Dug curved walls rather than straight	X	
Dirt had to be moved twice because instructions did not specify leaving room for 36-in. plastic sheet		X
Could not always tell whether illustration indicated measurement in feet or inches		X
Uncertain whether or not to remove car seats; illustrations are conflicting		X
Drove car into trench; collapsed	X	

Feasibility of construction. Given the relatively low safety of this type of shelter in a nuclear blast, and the additional concern of a car caving in on a trench constructed in unstable ground, this design was not considered to be highly advisable, though feasible (see Table 8 for other problems). Additional concerns revolved around the fact that wheelbases for automobile vary so radically between large luxury cars and small compacts that a uniform set of measurements may well be impossible. Furthermore, old-vintage automobiles may well deposit a periodic residue of oil, gasoline, and antifreeze upon the inhabitants of the trench, making habitation very uncomfortable. The danger of a cave-in and earth tremor during an after-shock might possibly constitute a greater danger than the nuclear attack itself (see Figs. 4.16 and 4.17).



Fig. 4.16. Successfully completed Car-Over-Trench Shelter.



Fig. 4.17. Rear left wheel of car driven too close to side of trench. Left wheel sank into earth, as edge of trench collapsed inward, until frame of car rested on ground.

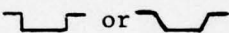

Suggestions for improvements

1. Instructions should clearly indicate that as the trench is being dug the dirt should be piled to allow room for the car in addition to 36 in. of plastic on the sides of the car. This point was not clear, necessitating the removal of dirt several times rather than only once.

2. Illustrations were not printed large enough to read well. Especially the measurement figures need to be more readable.

3. The illustrations should be congruent. One shows the seats left in, the other with seats taken out.

4. The entrance needs to be illustrated showing 5 in. from the regular trench on both sides.

5. The instructions need to emphasize the wall structure being either perpendicular or slanted inward for strength:  or 

6. Illustrations are needed every few steps at a time in addition to the complete overview.

7. The plans would be easier to follow if the steps were laid out in 1, 2, 3 order rather than 1, 3, 4, 6, 8, etc., as is presently the case.

8. Specify the distance between the top of the earth-filled bags and the underside of the car.

9. Instructions should specify that the dirt must come up above the wheel housing.

4.4 Aboveground Door-Covered Shelter

Group composition. The first group was a married couple who performed most of the excavation work with the assistance of coffee cans in lieu of shovels. The second group consisted of a 29-year-old father, a 27-year-old mother, and a daughter of 4.

Communication-construction problems. Both groups shared two problems: (1) the earth rolls bulged inwardly when the doors serving as temporary braces were taken away, and (2) some dirt slid off the entrances and into the shelter. Other problems encountered by only one family included making the trench too wide for the temporary door braces, a problem which later was rectified; the addition of unnecessary sandbags;

uncertainty regarding how to secure the ends of the sandbags; lack of understanding regarding how to make earth rolls; disagreement regarding interpretation of the instructions in the selection of a shelter location. A list of materials used in constructing this shelter is given in Table 9.

Table 9. Materials used in constructing an
Aboveground Door-Covered Shelter

	Group No.	
	1	2
Group size	2	3
Workers	2	2
Nonworkers	0	1
Tools and materials		
Shovels	2	2
Axes	0	0
Picks	1	0
Hammers	1	1
Saws	1	1
Nails	0	* ^a
Knives	0	0
Lanterns	0	0
Crow bar	0	0
Rakes	0	0
Hoes	0	0
Shears	0	0
Measuring tape (rulers or yardstick)	0	0
Gloves (pairs)	0	0
String or rope	0	0
Sheets	6	6
Pillowcases	0	0
Buckets	0	2
Coffee cans	1	0
Wood	0	*
Materials supplied		
Doors	*	*
Plastic covering	*	*
No. times design consulted	26	17
Length of time consulted, min	?	83
Actual construction time, hr	18.7	13.5
Total time involved, hr	32	21.5

^aDesignates use rather than a specified number.

Feasibility of construction. Both groups demonstrated that this particular design is very feasible to construct with rudimentary tools and ordinary household materials (see Table 10 for problems encountered). Further details of this shelter are shown in Figs. 4.18 through 4.21.

Table 10. Problems in communication and construction encountered by two groups constructing the Aboveground Door-Covered Shelters

Problems encountered	Groups encountering problem	
	1	2
Disagreement regarding where to begin trench	X	
Did not make earth rolls as thick as specified		X
Could not understand what earth-filled rolls were (coincidentally improvised with pillowcases)	X	
Earth rolls bulged inwardly when doors taken away	X	X
Dirt slides off the entrance	X	X
Started trench out too far and had to move it in	X	
Shelter was made too long because sandbags added unnecessary length		X
Uncertain how to secure ends of sandbags; sand ran out after they were in place	X	



Fig. 4.18. Interior doors used for forms, preparatory to using bed-sheet fabric to make earth-roll walls.



Fig. 4.19. Roofing on partly completed Aboveground Door-Covered Shelter. The last roofing door had not been placed.

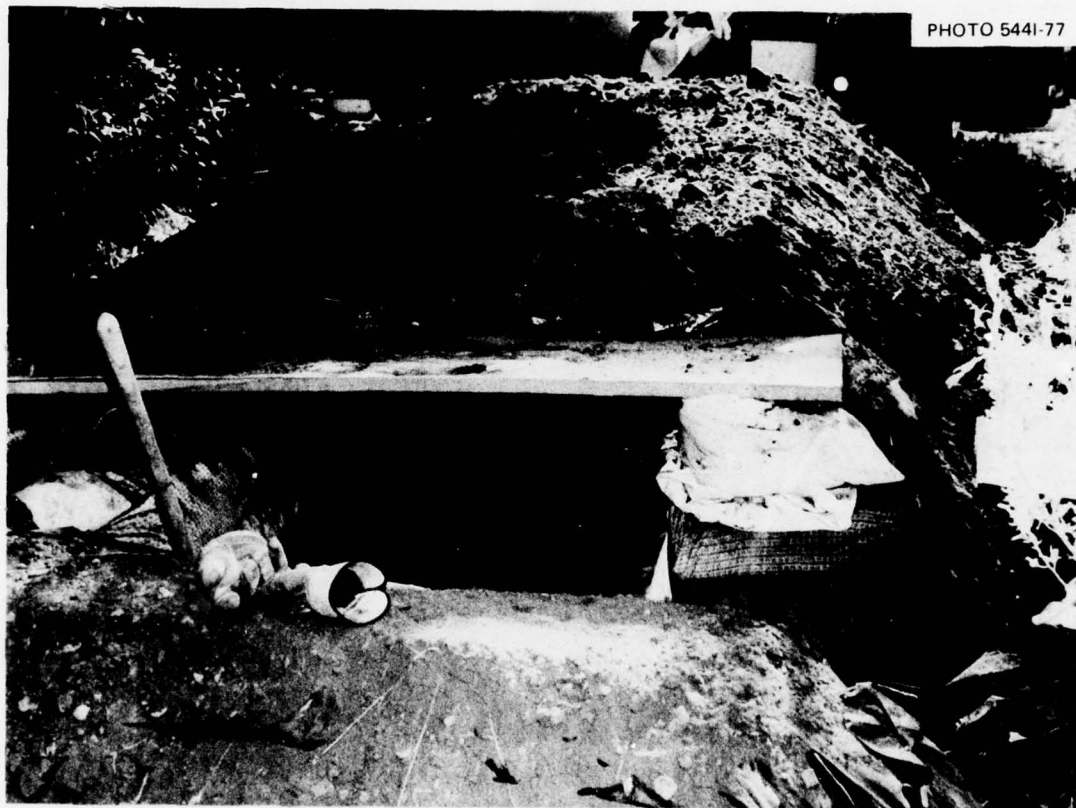


Fig. 4.20. Nearly completed entrance of an Aboveground Door-Covered Shelter. Instructions for making an earth roll over the door, or placing 2 sandbags over the door, should be added.



Fig. 4.21. Completed Aboveground Door-Covered Trench Shelter. This ground suggested sandbags be placed at side of and above entrance before putting earth rolls in place in order to prevent dirt from falling into entrance.

Suggestions for improvements

1. Instructions need to specify pulling the sheets on earth rolls so they are tight, so that the inner walls will remain vertical after the door forms are removed. The approximate amount of dirt inside the rolls should also be specified.

2. A brief explanation is needed regarding why an earth roll is needed above entrances, for example, to keep dirt from falling into the shelter.

3. Illustrations and instructions need to specify that the sandbags go into place before the earth rolls.

4. Steps should be listed in sequential order with more simplified illustrations of every few steps.

5. It is not clear whether "earth-filled rolls" refer to sandbags. It should be specified that the ends of the sandbags need to be tied.

6. More specification is needed regarding where the trench is located in relation to the total structure, that is, whether it extends the full length of the shelter.

7. A more explicit diagram of the construction of the entrance would be very helpful.

8. Step 4 might be reworded to eliminate redundancy.

9. Between steps 2 and 3 there need to be instructions stating that the sandbags should be set in place prior to setting the earth rolls in place.

10. Between steps 6 and 7, instructions should specify that the sandbags should be placed on the door over the entrance before the dirt is placed on top.

11. Because both doors and people vary in width, some specification regarding the minimum space per person should be included.

12. The number of sandbags needed to close off the doors should be specified.

13. The plans should specify that the door frame for the entrance should be made to fit before the remaining doors are placed in position.

14. Fitted sheets work especially well for making the earth rolls closest to the entries, because they keep the dirt from falling into the entrance. (Not understanding how earth rolls are made, some individuals

tore their fitted sheets at the corners so that sheets would lie flat. As a matter of fact, fitted sheets are suited to make perfect earth rolls if they are left intact).

4.5 Crib-Walled Shelter

Group composition. Group 1 was a family of four with a 44-year-old father, a 38-year-old mother in somewhat fragile health, and two sons 16 and 12. The mother had just recently been released from the hospital; however, she worked right along with her husband and boys in constructing the shelter.

The second group consisted of two young married couples in their twenties, each of whom had an infant child. The major portion of the construction was performed by the two husbands and one of the wives. This unconventional configuration of participants again represented an attempt to approximate different possible combinations of groups and families who might need to combine forces to construct a shelter for an impending nuclear attack.

Communication-construction problems. The major problem confronting both groups was a failure to determine the actual pitch of the roof. The instructions indicate the need for a slanting roof, but they were ambiguous regarding whether the direction of the slant is north-south or east-west.

As was the case with several other shelter designs, a brief explanation regarding the function of earth as both a blast protection barrier and a nuclear radiation shield would be helpful to participants. Each of the groups was uncertain whether it was necessary to fill cracks between the cribs and also how full to make the cribs. If the reasons were given why certain procedures were prescribed, groups would be more inclined to build tigher shelters, heap the dirt higher, build more substantial canopies and entrance barriers, etc.

Both groups had some difficulty in following the inside measurements of the Crib-Walled Shelter so that the entrance would be wide enough but not be so wide that the roof logs were too short to cover the shelter.

Additional areas of relatively minor concern which were corrected through trial and error included the total absence of rope or wire in one shelter, necessitating the use of cloth strips, uncertainty regarding how to make earth rolls, and uncertainty whether the "long side" mentioned in the instructions referred to a crib or to the whole shelter wall (see Table 11 for list of materials).

Table 11. Materials used in constructing a Crib-Walled Shelter

	Group No.	
	1	2
Group size	4	4
Workers	4	4
Nonworkers	0	0
Tools and materials		
Axes	1	1
Saws	1	2
Rakes	1	0
Picks	1	0
Shovels	3	2
Scissors	1	0
Buckets	1	2
Gloves (pairs)	4	0
Sheets	* ^a	0
Hammers	0	1
Pillowcases	*	*
String or rope	0	*
Measuring tape	0	*
Materials supplied		
Poles	*	*
Plastic sheets	*	*
Actual construction time, hr	34	22
Total time involved, hr	48	42.7

^aDesignates use rather than a specified number.

Feasibility of construction. In some regards these instructions were easier to follow than any of the others. However, the sheer labor involved in cutting logs, securing the logs together to form the cribs, filling the cribs, and covering the roof constituted a very demanding

physical effort. This shelter should definitely be recommended only for those with fairly large families, or groups with several members capable of strenuous labor.

During the debriefing a few days after their shelter had been completed, the 44-year-old father of two made the following poignant observation: "When we first began working on the shelter I said to myself, 'We'll never finish this within two days.' Then, after we'd worked on it for a few hours I thought, 'We'll never finish this within two weeks.'"

They did, however, finish the shelter within the prescribed length of time, notwithstanding the fact that the mother of the family required medical attention during the days that followed.

The most important constraints on the feasibility of constructing this shelter rest with the need for: (1) a large number of fairly straight and readily available logs; (2) the type of soil which can be rather densely compacted and fairly easily dug; and (3) an inordinate number of bed sheets which the typical family simply would not have on hand (see Table 12 for other problems). Other details of construction are shown in Figs. 4.22 through 4.26.

Table 12. Problems in communication and construction encountered by two groups constructing the Crib-Walled Shelter

Specific problems	Groups encountering problem	
	1	2
Uncertain how full to make the cribs	X	
Did not have rope or wire	X	
Uncertain how to strengthen cloth strips by braiding, twisting, etc., in order to use in lieu of rope	X	
Outside measurements were correct, but inside measurements were incorrect; roof logs were too short	X	
Uncertain how to make earth rolls; succeeded through trial and error	X	
Uncertain which way to slant the roof	X	X
Uncertain whether it was necessary to fill cracks between the cribs; did not realize radiation problem		X
Made entrance too narrow to pass through		X
Uncertain which wall was referred to as the "long side"		X



Fig. 4.22. This family, who constructed a Crib-Walled Shelter, discovered that in order to fill the cribs and cover the roof, this aboveground shelter required more digging than many trench-type shelters.



Fig. 4.23. Crib walls which have been lined and are ready to be filled. Note the use of bed-sheet strips used in lieu of rope and wire.

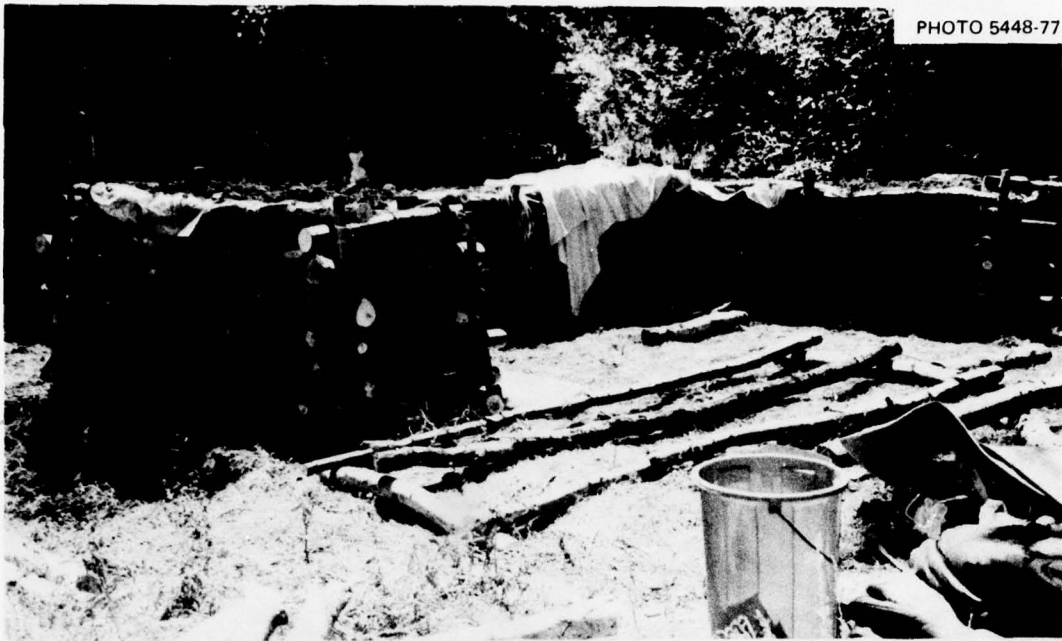


Fig. 4.24. Exterior crib walls.

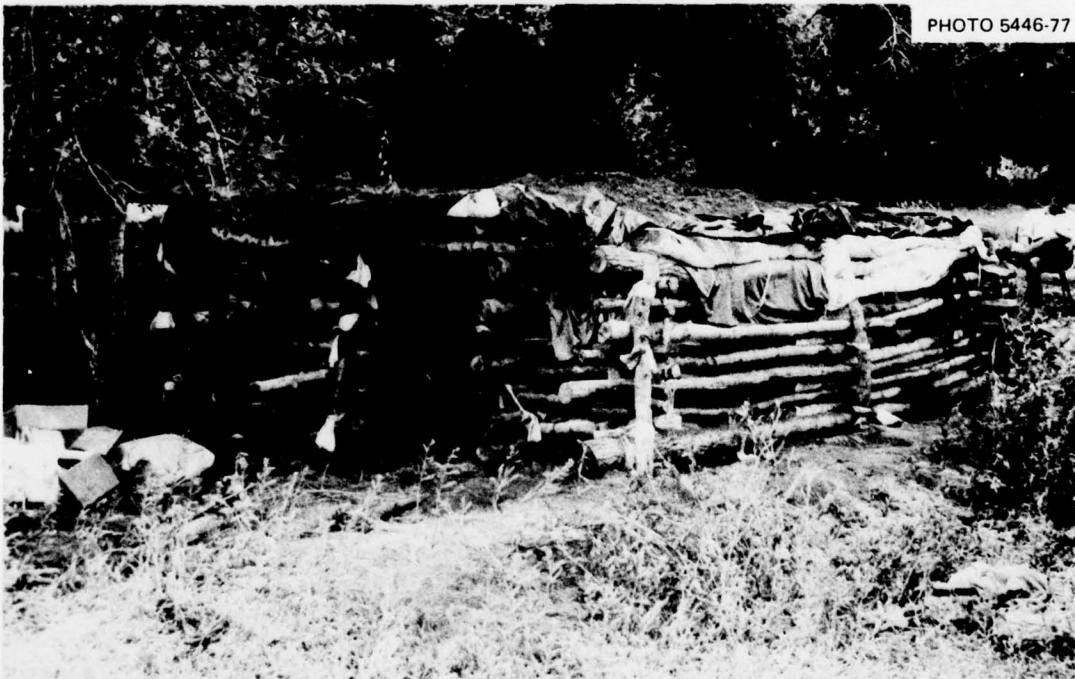


Fig. 4.25. Crib-Walled Shelter prepared for earth-covered roofing.



Fig. 4.26. A nearly completed Crib-Walled Shelter.

Suggestions for improvements

1. Directions are needed for filling the cracks between the cribs.
2. The shelter should be suggested only for families with at least three adults, two of whom need to be male. Otherwise, the time element would make the shelter unfeasible.
3. When instructions indicate "the long side," they need to specify whether that is the long side of the crib or long side of the shelter.
4. There is not enough room to pass through the passageway if instructions are followed meticulously, because the pole ends stick out beyond the measurements given. If the wall is moved out to allow for passage, the roof log length is then inaccurate. Instructions need to be corrected.
5. An illustration or instructions should specify which direction the slant for the water runoff should be. The current illustration does not clarify whether the pitch runs north-south or east-west. Drainage should always be away from entries.
6. No typical household would have the specified number of bed sheets on hand. Alternative substitutes should be suggested.
7. Illustrations of the full crib from different angles would be helpful.
8. Directions need to be larger and clearer, with more detailed illustrations showing a few steps at a time.
9. Instructions need to be given regarding how to make an earth roll, for example, include the diagram from the Door-Covered Trench design.
10. The list of materials needed should include one bucket and shovel per person if at all feasible.
11. Suggestions should be made for selecting a site which provides ready availability of dirt to cover the shelter and fill the cribs.
12. An end view of the shelter would help individuals conceptualize how the entrances and crib walls should be constructed.
13. The list of materials should indicate that torn and braided bed sheets may be used in lieu of rope or wire if sheets are not available.

4.6 Ridge-Pole Shelter

Group composition. This particular shelter design is so complex and involves so many hours of labor to construct that two large families with older children were recruited to build it. The first family consisted of a 49-year-old father, a 42-year-old mother, and five children 18, 17, 16, 10, and 4. The four-year-old's contribution was primarily limited to dragging or carrying the smaller logs. All other family members worked very hard and shared the burden of construction.

The second family included a father of 50, a mother of 48, and four children ages 21, 18, 14, and 9. All shared the construction duties more or less equally.

Communication-construction problems. Table 13 is a list of materials used in constructing this shelter. As indicated by the data in Table 14, the first family encountered considerably more areas of ambiguity than did the second family. However, two problems were shared by both, and these dealt with the uncertainty regarding where to place the slanted entrance poles and the difficulty in keeping the dirt on the roof. Both families used sod and leafy boughs as dirt stoppers on the waterproofing layer of plastic.

The problems unique to the first family included a need for suggestions for selecting a shelter location, and a related problem of a need for a diagram with overall dimensions of the shelter. They nearly began to construct their shelter in a narrow, deep creek bed because the digging would be easy there. However, to have done so would not have allowed enough room for the shelter. They were also uncertain how long to make the footing log, how to construct the entryway, how to secure the plastic on the roof, and how to stabilize the vertical wall poles at the entrance.

Again pointing out the need for occasional explanation in addition to instructions, the first family filled the "filler spots" above the two entrances. To save time and labor they used log scraps, branches, and other debris to cover the filler spots and then finally covered them with a thin layer of dirt. Had they received an explanation regarding the need for the dirt to be densely compacted to shield against both

Table 13. Materials used in constructing a Ridge-Pole Shelter

	Group No.	
	1	2
Group size	7	6
Workers	7	6
Nonworkers	0	0
Tools and materials		
Shovels	5	3
Axes	0	0
Picks	1	1
Hammers	0	0
Saws	1	2
Nails	* ^a	*
Knives	0	0
Lanterns	0	0
String or rope	*	0
Gloves (pairs)	5	3
Buckets	2	2
Wheelbarrows	1	1
Measuring tape	1	1
Materials supplied		
Poles	*	*
Plastic sheets	*	*
No. times design consulted	18	14
Length of time consulted, min	130	85
Actual construction time, hr	22.5	18.25
Total time involved, hr	35.75	29.25

^aDesignates use rather than a specified number.

Table 14. Problems in communication and construction
encountered by two groups constructing
Ridge-Pole Shelters

Specific problems	Groups encountering problem	
	1	2
No suggestions for selecting location of shelter	X	
Diagram for step 3 does not show overall dimensions	X	
Uncertain how long to make the footing log	X	
Uncertain how to construct entry-way; relied on a hunch	X	
Uncertain where and how plastic should be placed on the slanted roof	X	
Uncertain where slanted entrance poles should go	X	X
Uncertain how to stabilize vertical wall poles at entrance	X	
Filled "filler spots" above entrance with logs and debris and covered with dirt	X	
Difficulty in keeping dirt on the roof; used sod and leafy boughs as stoppers	X	X
Needed more sheets than were specified in the plans		X
Did not recognize need for braces between the 14-ft poles		X

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FEASIBILITY OF CITIZEN CONSTRUCTION OF EXPEDIENT FALLOUT SHELTER--ETC(U)

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blast and radiation, they definitely would have been more highly motivated to use compacted earth in the filler spots instead of loose debris.

The two most notable problems encountered by the second family were a definite shortage of bed sheets and a failure to recognize the need for braces between the 14-ft poles.

Feasibility of construction. Generally speaking, the ability of both families to follow rather complex plans was admirable. Although both groups made a few false starts in various areas of construction, they were still able to rectify errors from misunderstood instructions and construct shelters which were very substantial.

It became apparent from the erosion on one shelter that had it been allowed to remain standing for several days during two canyon windstorms, the Ridge-Pole Shelter roof was so steep that wind following a nuclear blast may well have removed the earth on the roof to an unsafe depth. Further details of this shelter are shown in Figs. 4.27 through 4.33.

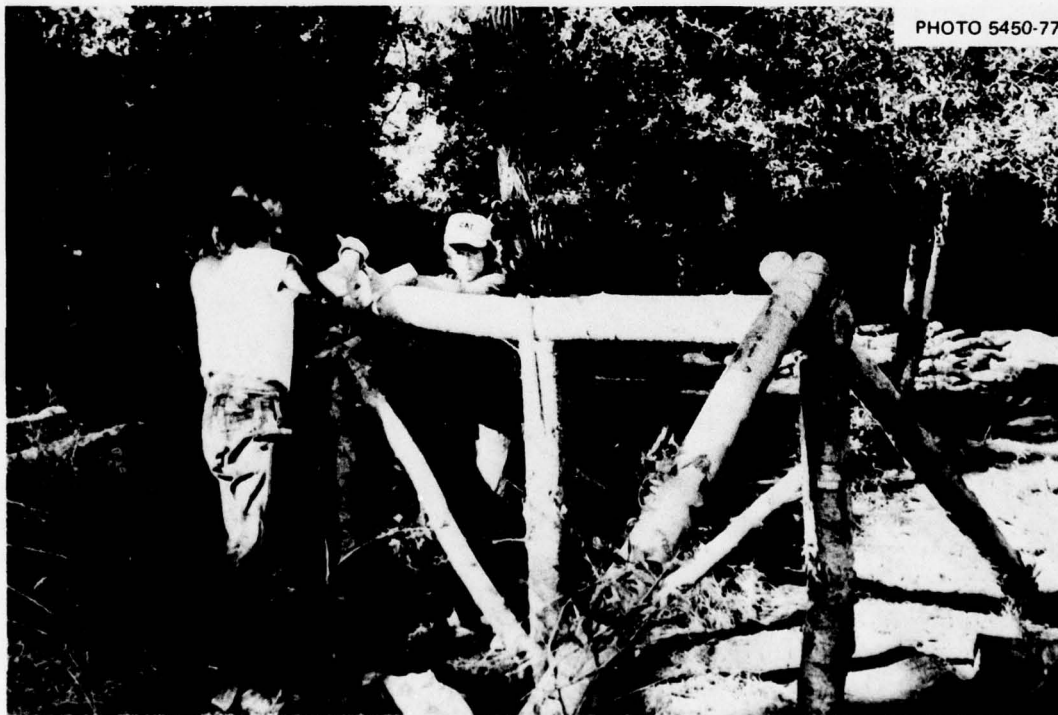


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Fig. 4.27. Making the frame of a Ridge-Pole Shelter.

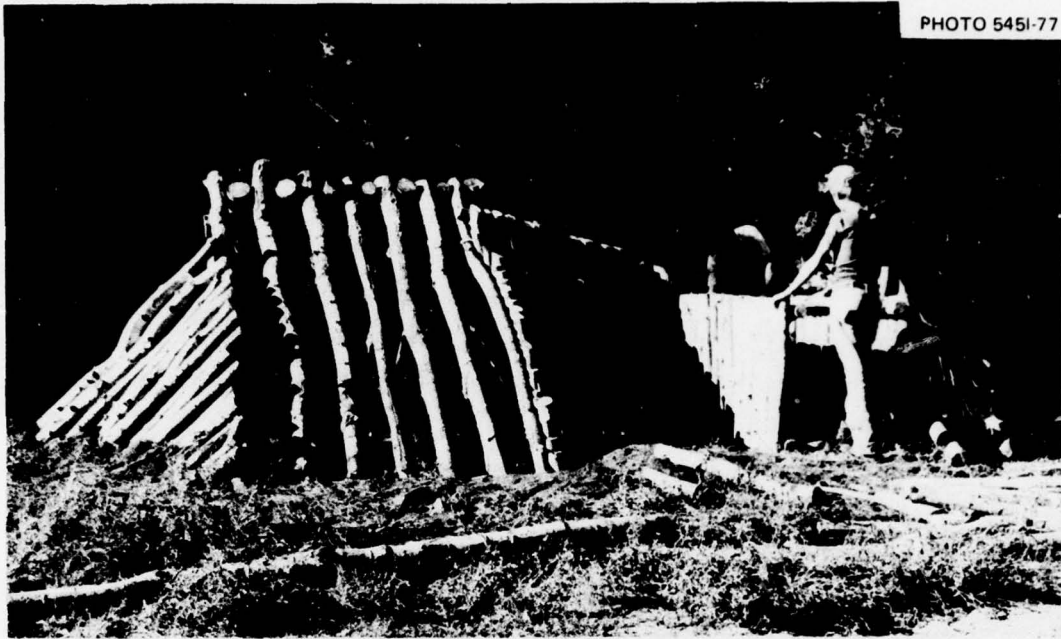


PHOTO 5451-77

Fig. 4.28. Side view of a ridge-pole frame.



PHOTO 5452-77

Fig. 4.29. Sticks placed horizontally. More sticks and limbs should have been used, although these few, when covered with 4-mil polyethylene, held the earth covering.



Fig. 4.30. Ridge-Pole Shelter nearing completion. The amount of earth required to cover the structure necessitates locating the shelter in an area where dirt can be easily excavated.



Fig. 4.31. One of the two right-angle entryways of Ridge-Pole Shelter, before being covered with earth.



Fig. 4.32. Interior view of Ridge-Pole Shelter.



PHOTO 5456-77

Fig. 4.33. Putting the finishing touches on a Ridge-Pole Shelter.

Suggestions for improvements

1. Some general guidelines are needed for choosing a location (i.e., not in a creek bed, not directly under trees which continually drop fallout, etc.).
2. Overall dimensions need to be specified in the diagram.
3. Specifications for lengthening the footing log need to be given.
4. The arrow showing the flow of traffic on the diagram of the entryway is confusing and unclear. A note is needed to explain what it means.
5. A diagram with arrows pointing to the exact placement of the roof plastic needs to be added to the worded explanation.
6. Clarification needs to be made on where the sloping entry poles go, that is, whether over the inside logs or under the outside logs.
7. It is unclear whether the vertical wall poles around the entryway are to be in a small trench, rolled, or just leaned against the frame. Clarification is needed.
8. The filler spots above the entrances take an enormous amount of earth and added time in digging. One group improvised by using other filler (i.e., logs and debris). Such improvisation is not safe, and an explanation should be given regarding why the earth fill is necessary.
9. Explicit suggestions should be given regarding the covering of the ridge-pole roof with dirt in such a way that the dirt does not slide off and attains an adequate density over the entire roof.
10. It may be well to suggest digging a "stand-up hole" inside this shelter so that taller inhabitants may stand up and stretch occasionally.
11. Step 3 could be simplified by breaking it down into substeps.
12. The list of materials needed should include a pickax or mattock for areas in which the soil is rocky or otherwise hard to dig.
13. The approximate square footage of plastic required should be specified.

4.7 Tilt-up Doors and Earth Shelter

- Group composition. Group 1 consisted of two young women, both age 18. Although they required considerably more time than the much larger

second group of participants, nevertheless, they completed the construction of this particular shelter design well within the specified time limit.

Group 2 consisted of a 38-year-old divorcee, her two daughters ages 18 and 16, and two sons ages 14 and 13. Unlike the first group, who spent considerable time resting, total time involvement for group 2 was 13 hr 35 min, of which 12 hr 40 min was spent in actual construction.

Communication-construction problems. Both groups were uncertain regarding how much area was to be covered by the plastic waterproofing material. Related to this problem was the difficulty encountered in keeping the dirt from sliding off the doors of both shelters. Group 1 did not fully comprehend how an air pump would fit the entrance.

Although, or perhaps because, group 2 constructed their shelter in a much shorter length of time than did group 1, group 2 encountered several more problems, including confusion caused by the cross-section or "cutout" diagram in the plans, uncertainty regarding how to construct the house footings to prevent the doors from slipping, uncertainty regarding how deep the earth should be piled on the roof and at the end of the shelter, and finally, their earth-fill stop began to tilt to a 135° angle rather than maintaining the 90° angle prescribed in the plan. See Table 15 for a list of materials used in constructing this shelter.

Feasibility of construction. Despite a number of minor communication and construction problems, this shelter design is, in many ways, one of the easiest and least time consuming to construct. However, one of the most pressing questions raised by participants, observers, and engineers is: What happens to the Tilt-up Doors and Earth Shelter in the event the wall of the building against which the shelter rests happens to collapse or the building catches fire in the wake of a nuclear thermal pulse? Otherwise, the shelter design and the ease of its construction appear to make it highly feasible (see Table 16 for some of the problems encountered). Figures 4.34 and 4.35 show some of the construction details.

Table 15. Materials used in constructing a
Tilt-up Doors and Earth Shelter

	Group No.	
	1	2
Group size	2	5
Workers	2	5
Nonworkers	0	0
Tools and materials		
Shovels	3	3
Picks	2	1
Hammers	1	1
Saws	2	1
Buckets	2	0
Knives	1	1
Plastic garbage bags	60	* ^a
Pillowcases	0	*
Sheets	0	*
Gloves (pairs)	0	5
String or rope	0	*
Measuring tape	1	0
Materials supplied		
Doors	4	6
No. times design consulted	9	16
Length of time consulted, min	65	100
Actual construction time, hr	17.25	12.7
Total time involved, hr	30.25	13.6

^aDesignates use rather than a specified number.

Table 16. Problems in communication and construction encountered by two groups constructing the Tilt-up Doors and Earth Shelter

Specific problems	Groups encountering problem	
	1	2
Illustrations do not show how much area is to be covered with plastic	X	X
Dirt kept sliding off doors	X	X
Uncertain how air pump would fit into entrance	X	
Confused by cross-section diagram		X
Uncertain how to construct entrance, inasmuch as that section was "cutout" of the diagram		X
Uncertain how to build house footings to prevent doors from slipping		X
Instructions were misleading regarding how high dirt was to be piled at the end of the shelter		X
Earth stop sagged from 90° down to 45°		X
Uncertain how deep the earth should be piled		X
Difficulty anchoring plastic before putting on first layer of dirt		X



PHOTO 5458-77

Fig. 4.34. End view of Tilt-up Door and Earth Shelter. It was a persistent challenge to keep dirt from sliding down the slanted doors.

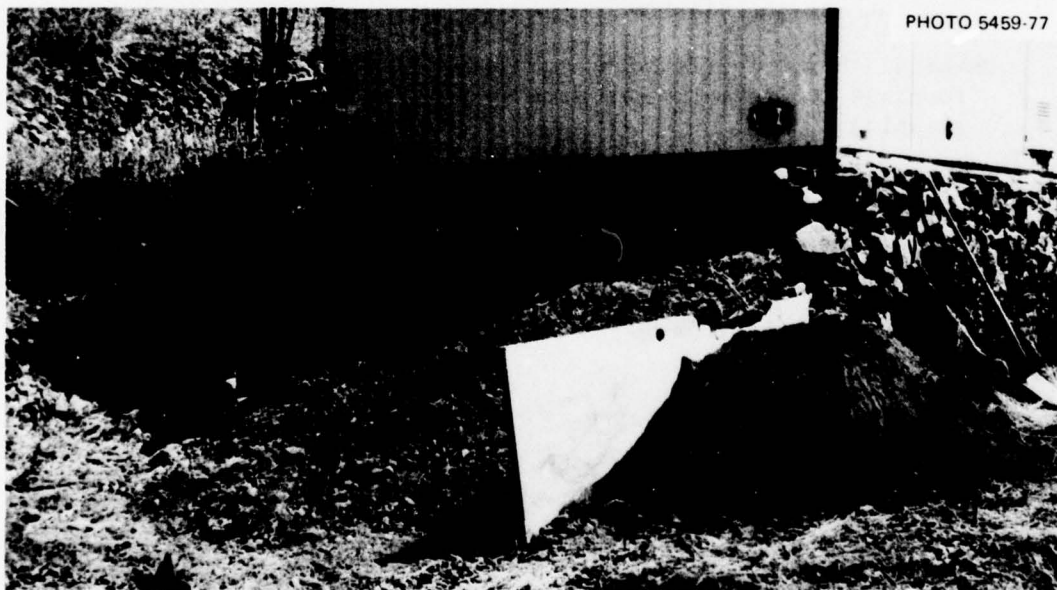


PHOTO 5459-77

Fig. 4.35. Closed end of a smaller Tilt-up Doors and Earth Shelter, built by two young women, indicating a weakness in the instructions. This photo shows a 3-ft-wide thickness of earth piled against the vertical door closing the end of the shelter. The instructions do not make clear that the sloping earth surfaces on both sides of this door should be the same height.

Suggestions for improvements

1. Specification is needed regarding how much of the shelter is to be covered by the plastic.
2. A note is needed suggesting that dirt be piled first at the base and then covered up to the top.
3. Directions need to be given on how the air pump would be installed in the shelter.
4. Instructions need to be printed larger and clearer so that illustrations, and particularly the measurements, are more legible.
5. The cross section needs to be done away with and replaced by several more specific illustrations which include just a few steps at a time; for example, both an elevated view and a top view together with one overall illustration of the completed shelter are needed.
6. Warnings need to be given not to move the trench too far from the house and not to make the slant of the doors too gradual. Alternatives need to be given for houses with shallow footings.
7. The dirt pile on the ventilation end needs to be at least as high as the roof doors; yet no mention is made, and the illustrations indicated otherwise.
8. To alleviate earth slippage and earth-stop sag, a note needs to be made suggesting putting the earth coverage on the bottom first, then working to the top.
9. There is difficulty putting the rainproofing plastic on before the first layer of dirt. Suggestions are needed regarding how to secure the plastic to the roof doors.
10. Step 4 should specify that about 6 in. of dirt be under the plastic and another 6 in. on top of the waterproofing material.
11. It seems that the entryways possibly need more protection.
12. Blast tremors might well cause the earth to slide off the roof unless some method is devised to prevent such slippage.

4.8 Construction of Air Pumps

One of the universal problems the participants encountered in constructing both the shelters and the air pumps was that both experiences

were totally novel and unique from anything they had previously observed. Thus, given merely descriptive instructions devoid of explanations regarding why things are done a certain way, it is not too surprising that some individuals and groups were unable to conceptualize the precise way to construct things.

Communication-construction problems. Most participants failed to understand the function of the flaps as valves that expel stale air and draw in fresh air. Thus, few of them were concerned about the inability of the flaps to swing freely on the pump. Most of them conceptualized the pump as merely a large fan used to "stir up" the air, rather than as a series of one-way valves. Table 17 is a list of materials used in constructing the air pumps.

Despite the fact that Table 18 reveals the prevalence of nine different problems encountered in the construction of the pumps, in most cases if the builders had been adequately informed, these problems could have been easily remedied so that the pump would have operated properly.

The most common problem encountered was the excessive overlapping of the flaps, which prevented them from allowing a free air flow. The instructions indicate that the pivot wires which hold the flaps should be spaced equidistantly at 3-1/4 in. intervals. They also specify that after fashioning the hem tunnel through which the pivot wire is placed, the flaps should be 4 in. wide. Thus it should be evident that each flap will overlap three-fourths of an inch each succeeding flap. However, because the instructions do not explain the function of the flaps, many participants saw no reason why the flaps could not overlap as much as 3 in. An overlap greater than about 1 in. prevented the flaps from performing their functions as an air flow valve. In most cases the flaps could have been easily trimmed with scissors or a knife so that the overlap would create no problems.

Aside from the problem of overlapping flaps, most other departures from the prescribed design were unique to each group of participants. These problems included (1) a failure to make the center notches in the flaps wide enough to swing freely without being bound up on the center brace; (2) the use of thumbtacks where heavy staples, nails, or wall tacks are necessary; (3) securing the pivot wire too closely to the

Table 17. Materials used in the construction of eight representative air pumps

	Pump No.							
	1	2	3	4	5	6	7	8
Outside dimensions, in.	12-3/4 x 18	29-1/4 x 36	26 x 27-1/4	29 x 36	8 x 11	29 x 36	19 x 36	22-3/4 x 30-1/2
Inside dimensions, (air flow), in.	8-3/4 x 14-3/4	25-7/8 x 33	22-1/4 x 23	25-3/4 x 32	4-3/4 x 9-1/4	26 x 33	17 x 33	20 x 26
Flap material	X	X						X
Polyethylene film			X	X				
Garbage bags					X			
Raincoat fabric							X	
Window shade fabric								X
Flap dimensions, in.	4-1/2 x 11-1/2	4-3/4 x 29	4-1/2 x 26	4-3/4 x 28-1/2	2-3/4 x 9-3/4	4-1/2 x 29	4 x 19	4-1/2 x 24
Number of flaps	5	11	10	10	6	10	7	8
Overlap with next flaps, in.	1-1/4	1 - 1-3/4	2-1/8 - 2-3/4	1 - 3	2	7/8 - 1-1/8	1/2	3/4 x 2-1/8
Flap pivot:								
Wire	X	X		X	X	X	X	X
Nylon string			X					
Insulated wire								
Tape used for hems								
Masking								
Pressure sensitive		X		X			X	X
Strapping tape			X					
Heating duct tape					X			
Flap stops material								
Wire mesh		X	X	X				X
Thread	X							
Heavy string						X	X	
Flap stops secured by:								
Thumbtacks	X							
Nails			X		X			
Heavy staples		X		X		X	X	X
Glue								
Type of hinge								
Cabinet								
Vinyl	X	X	X		X	X	X	X
Novel				X				

Table 18. Communication and construction problems encountered in building eight representative air pumps

	Pump No.							
	1	2	3	4	5	6	7	8
Notches in flaps not big enough; flaps bound on center brace	X							X
Thumbtacks too weak to securely hold vinyl hinges	X							
Pivot wire was secured directly against wire mesh; prevented free flap movement		X						X
Flaps overlapped too far to allow adequate air flow			X	X	X			
Pivot wires flimsily secured only by thumbtacks	X							
Pivot wire so crooked the flaps could not swing freely		X						X
Nylon string used for "pivot" wire" began to sag, impeding flap from swinging				X				
Flap material too heavy					X			
Inadequate overlap							X	

wire-mesh flap stop; (4) failure to straighten crooked pivot wire; (5) the use of stretchable, thin nylon string for a pivot wire, and (6) the use of so-called raincoat material, which is much too heavy for use as flaps.

Although the air-pump instructions are undoubtedly intended to provide the inexperienced builder with numerous options, alternative suggestions were sometimes confusing, communicating to some participants great latitude in the design itself. For example, if flaps can be made from either polyethylene film, trash-can liners, or raincoat material, some participants inferred that it is, therefore, not necessary to strictly adhere to a flap width of 4 in. This caused problems of excessive overlapping.

Representative of the myriad options provided the novice builder is a parenthetical statement included in step 2 which indicates that materials for the air-pump plans are "sized for a 36-inch by 29-inch pump." While any experienced builder would find scaling down a set of blueprints to be an easy task, this proved to be difficult for some of those building air pumps for shelters using a size somewhat different from the standard 29 × 36 in. design.

The following are additional alternatives provided in the selection of building materials:

- Step 2a. "Lumber sizes can be altered, depending on availability."
- b. "One pair ordinary door OR cabinet butt hinges, OR metal strap hinges, OR improvised hinges made of leather, woven straps, cords OR four hook & eye screws which can be joined to form two hinges."
- e. " . . . straight wire for use as flap pivot wires . . . OR cut from 10 wire coat hangers, OR 35' nylon string (coat-hanger wire thickness)."
- f. "30 small staples, or small nails, or 60 tacks to attach flap pivot wires to wood frame."
- h. " . . . 90 tacks or small nails to attach flap stops to the wood frame, OR stops can be tied to the frame."

It should be helpful to inexperienced builders to suggest alternative materials. However, the suggested alternatives were not always readily understood. For example, without a "spoon-fed" explanation that leather hinges (2h above) must be secured with nails, one enterprising builder used thumbtacks, which worked loose after a few trial swings. In summary, it appears to be necessary to provide a brief explanation regarding which substitutions would most critically alter the proper functioning of the pump (see Figs. 4.36 through 4.39 for further details).

PHOTO 5460-77

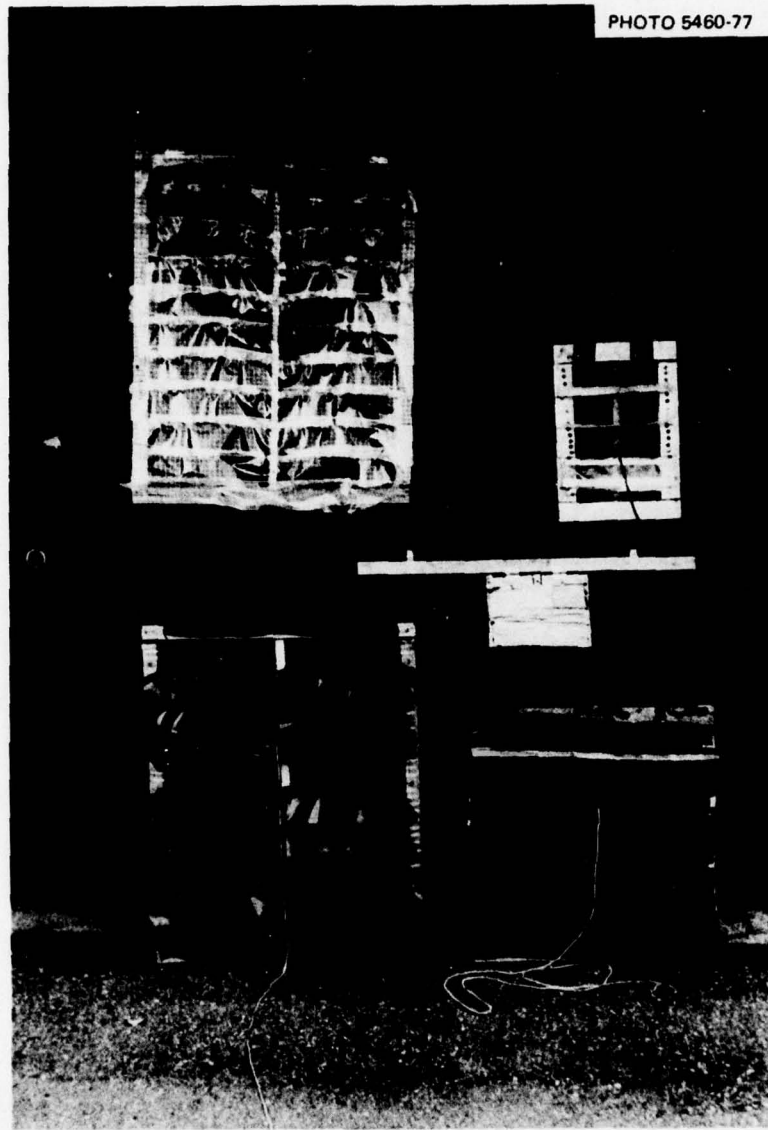


Fig. 4.36. Upper left - Note the crooked pivot wires, which prevented flaps from swinging freely. Upper right - Vinyl hinges are secured by thumbtacks, as are the pivot wires. After minimal use, both hinges and pivots came loose. Middle - Pump made to fit into a small entrance in a Door-Covered Trench Shelter. It has six flaps covering a distance of 8 in., thus preventing air from flowing through. Lower left - This was one of the properly constructed pumps which operated very well under test conditions. Lower right - The flaps on this pump overlapped too much and prevented a free flow of air through the pump.

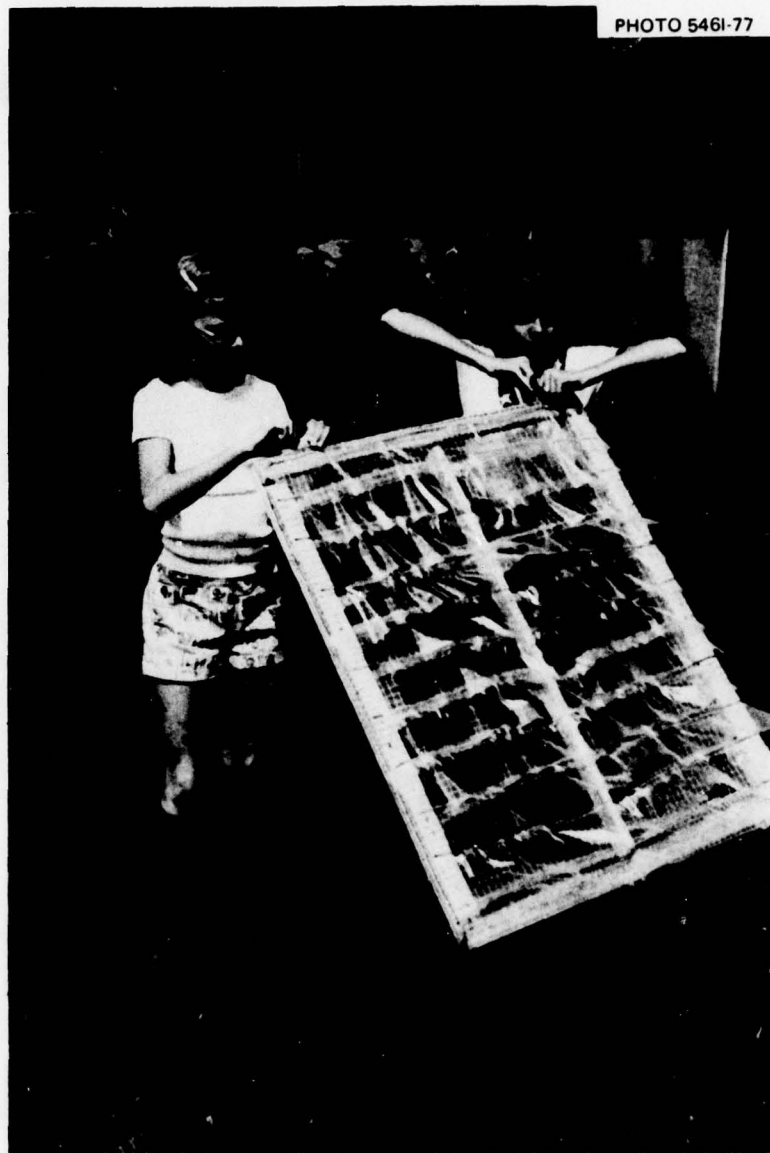


Fig. 4.37. Although this pump was constructed in accordance with the design instructions, the pivot wire was secured directly against the wire mesh used as a flap stop. The heavy pivot wire was also very crooked. Both of these problems combined to prevent the flaps from swinging freely under ordinary operating conditions.

PHOTO 5462-77



Fig. 4.38. The group who constructed this pump interpreted the use of "tacks" in the instructions as referring to thumbtacks. Although thumbtacks were sufficiently strong to secure the thread used for flap stops, they were definitely not suited for securely holding the vinyl hinges or pivot wires.

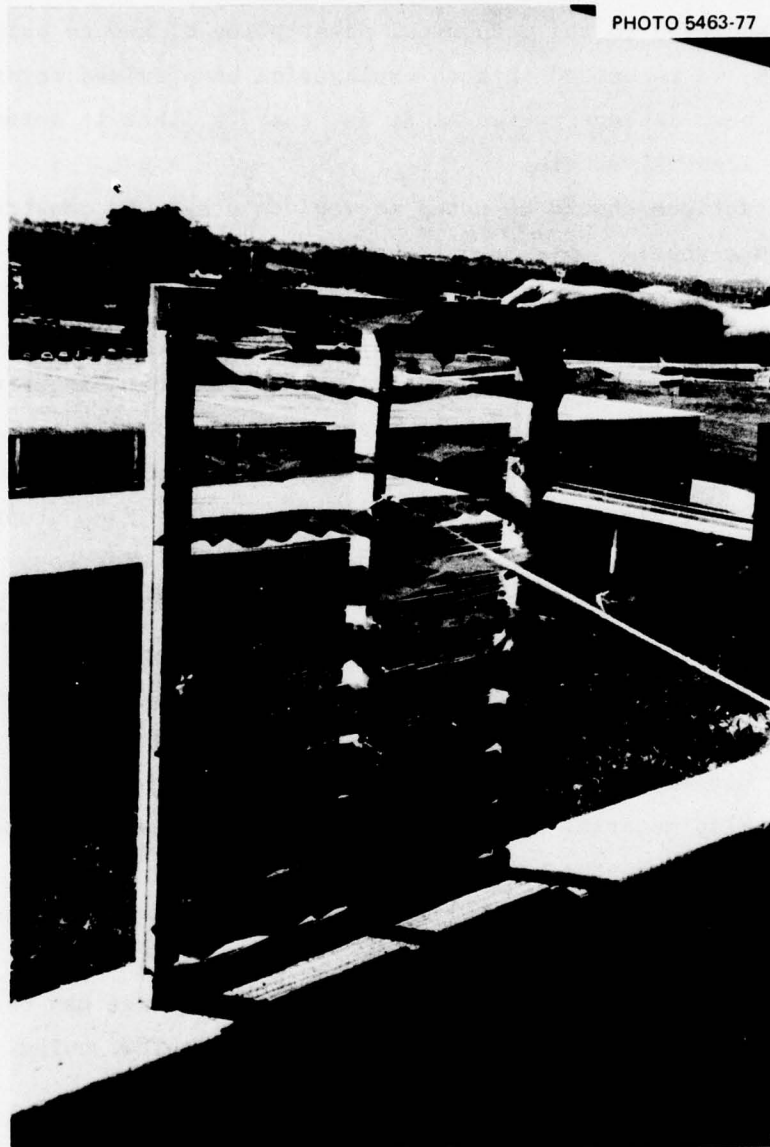


Fig. 4.39. This is a properly constructed air pump which conforms to the measurements and use of materials specified in the two-page instructions.

Suggestions for improvement of air-pump instructions

1. In addition to the methodical description of how to build the air pump, we recommend that an explanation be provided regarding why the pump is constructed as it is, that is, that it serves as an air flow valve, etc.
2. Precautions should be noted at various stages of construction to ensure that:
 - a. Pivot wires are equidistant.
 - b. Pivot wires are straight.
 - c. If nylon string is used, it must be of coat-hanger thickness and be kept taut so the flaps can swing freely.
 - d. Pivot wires must be secured by heavy staples or nails.
 - e. Pivot wires should not be secured against flap stops, especially wire mesh, which impedes the flapping of the stops.
 - f. Center notches in flaps are wide enough to swing freely around the center brace without binding.
 - g. Because the pump may be in operation from several hours or even days, it is necessary to secure cabinet hinges or leather hinges with screws.
 - h. Flap material is light enough to swing freely on the pivot wire when the pump is in operation.
 - i. Flaps should not overlap more than 3/4 to 1 in. onto succeeding flaps.
3. Instructions should specify how a butt hinge may be attached to a structure in such a way as to allow at least a 180° swing.

APPENDICES

Appendix A

BASE PAY RATE AND BONUSES FOR CONSTRUCTION
OF EACH SHELTER DESIGN

Design No.	Description	Base pay	Bonus	Total
1	Door-Covered Trench	\$285	\$190	\$475
2	Log-Covered Trench	\$310	\$200	\$510
3	Crib-Walled	\$385	\$255	\$640
4	Ridge-Pole	\$820	\$540	\$1360
5	Aboveground Door-Covered	\$375	\$245	\$620
6	Tilt-up Doors and Earth	\$310	\$200	\$510
7	Car-Over-Trench	\$200	\$120	\$320

Some discretionary adjustments were made in the above amounts after it was discovered that, for example, the man-hours involved in constructing the Crib-Walled Shelter were nearly as great as those required for constructing a Ridge-Pole Shelter. Our recommendations for total pay in the event of future construction of these seven shelters would roughly approximate the following:

1. Door-Covered Trench	\$475
2. Log-Covered Trench	\$510
3. Crib-Walled	\$1000
4. Ridge-Pole	\$1000
5. Aboveground Door-Covered	\$620
6. Tilt-up Doors and Earth	\$400
7. Car-Over Trench	\$320

Appendix B

AGREEMENT

We, the undersigned, for ourselves and as guardians of our minor children listed below, agree to abide by all the conditions and terms of the foregoing contract. We hereby waive all claims for personal injuries or damage to property we or our minor children may experience as a result of our participation in this project against Brigham Young University, the Oak Ridge National Laboratory, Union Carbide Company, and their officers, employees and agents, and agree to hold such corporations and individuals harmless from all such claims. We further certify that we are in good health and fit for strenuous work. We have health, life and accident insurance or have decided not to obtain such insurance after having been advised to do so.

We hereby agree to construct a nuclear fallout shelter according to plans and specifications to be furnished us and to commence construction within 10 hours after receiving notice. We agree as a family to construct Shelter Design No. _____ for a base pay of \$ _____. A bonus of \$ _____ will be paid to our family if construction is completed within _____ hours after the commencement of the project. Payment will be made within fifteen (15) days after the completion of the project.

(Date)

Principal Investigator

Notary Seal

EXPEDIENT FALLOUT

DOOR - COVERED TRENCH SHELTER

STEP 1

SELECT A LEVEL SITE AND DETERMINE THE SHELTER LENGTH MEASURING OR LAYING DOORS SIDE BY SIDE. DO NOT FORGET TO REMOVE DOOR KNOBS.

STEP 2

EXCAVATE THE SHELTER TRENCH, ENTRYWAY AND VENTILATION TRENCH. AT THE SAME TIME PILE THE EXCAVATED EARTH AT LEAST 3 FT BEYOND THE TRENCH SO THAT IT WILL NOT INTERFERE WITH PLACEMENT OF THE DOORS OVER THE OPEN TRENCH. SEE FIGURE 1.

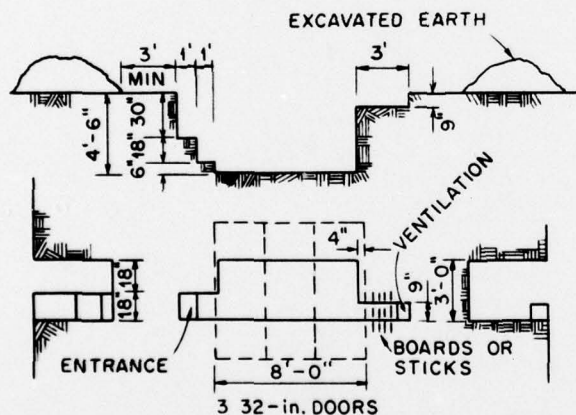


FIGURE 1
LAYOUT FOR 3-PERSON CAPACITY

STEP 3

THE WALLS OF THE TRENCH MUST BE VERTICAL. WITH SHEETS OR FABRIC LINE THE WALLS OF THE SHELTER THEN PLACE THE DOORS OVER THE OPEN TRENCH AS SHOWN ON FIGURE 1.

STEP 4

CONSTRUCT EARTH ROLLS OR PUT SANDBAGS AROUND THE ENTRYWAY AND VENTILATION TRENCH IN ORDER THAT THE EARTH CAN BE HELD IN PLACE AROUND BOTH OPENINGS. SEE FIGURE 2.

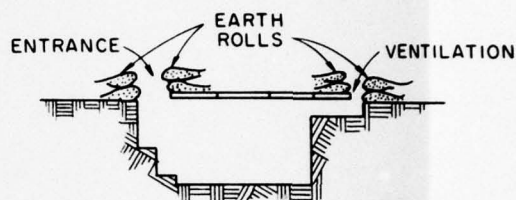


FIGURE 2

STEP 5

PLACE EARTH FILL OVER THE DOORS. BEGIN BY PLACING 1-FT DEEP FILL AROUND THE EDGES AND COMPACT IT WITH THE BACK OF THE SHOVEL, THEN FILL OVER THE DOORS TO FORM A SMALL MOUND. PLACE THE WATERPROOFING OVER THE MOUND. REPEAT AGAIN BY PLACING 1 FT AROUND THE EDGES FIRST AND THEN ON THE CENTER. SEE FIGURE 3.

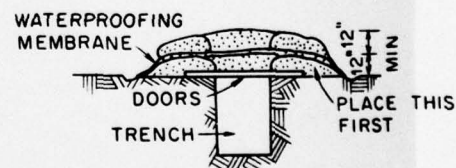


FIGURE 3

STEP 6

CONSTRUCT SHALLOW DRAINAGE DITCHES ON ALL SIDES AND PLACE OPEN SIDE CANOPIES OVER THE OPENINGS. SEE FIGURE 4.

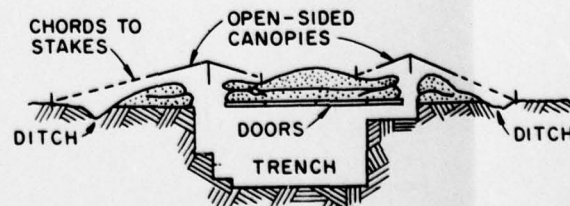


FIGURE 4

Appendix C
SUGGESTED REVISION OF LAYOUT FOR DOOR-COVERED TRENCH SHELTER

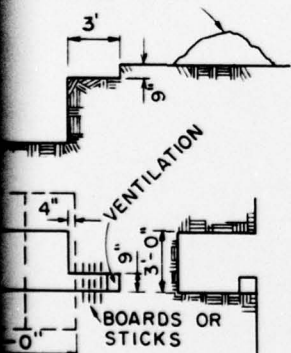
GRADIENT FALLOUT SHELTER

DOOR-COVERED TRENCH SHELTER

TERMINE THE SHELTER
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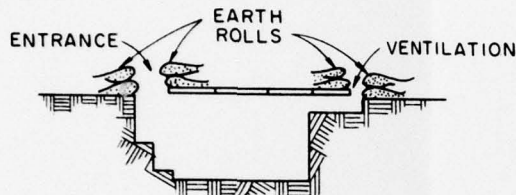


FIGURE 2

STEP 5

PLACE EARTH FILL OVER THE DOORS. BEGIN BY PLACING 1-FT DEEP FILL AROUND THE EDGES AND COMPACT IT WITH THE BACK OF THE SHOVEL, THEN FILL OVER THE DOORS TO FORM A SMALL MOUND. PLACE THE WATERPROOFING OVER THE MOUND. REPEAT AGAIN BY PLACING 1 FT AROUND THE EDGES FIRST AND THEN ON THE CENTER. SEE FIGURE 3.

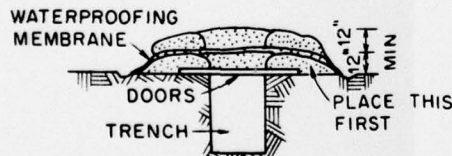


FIGURE 3

STEP 6

CONSTRUCT SHALLOW DRAINAGE DITCHES ON ALL SIDES AND PLACE OPEN SIDE CANOPIES OVER THE OPENINGS. SEE FIGURE 4.

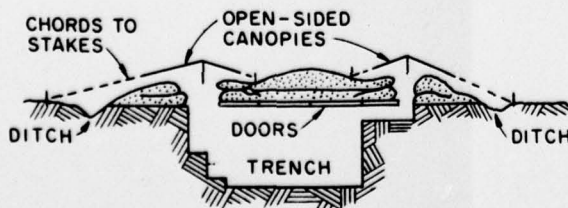


FIGURE 4

TOOLS AND MATERIALS

1. DOORS (INTERIOR SOLID OR HOLLOW-CORE) - 1 FULL SIZE (32" MINIMUM WIDTH) FOR EACH PERSON. IF DOORS MEASURE LESS THAN 32" IN WIDTH, USE A COMBINATION OF DOORS TO PROVIDE THE MINIMUM WIDTH PER PERSON.
2. PICK AND/OR MATTOCK.
3. LONG-HANDLED SHOVELS.
4. RAINPROOFING MATERIAL - (e.g., PLASTIC SHEETING, CANVAS, PLASTIC TABLE COVERS, ETC.) AT LEAST 25 SQUARE FEET PER PERSON PLUS 2 PIECES ABOUT 6 FT. by 6 FT. FOR USE AS CANOPIES.
5. ONE BEDSHEET OR THE EQUIVALENT OF 50 SQ. FT. OF CLOTH OR PLASTIC PER PERSON TO LINE TRENCH AND MAKE EARTH-FILLED ROLLS.
6. TWO PILLOWCASES PER PERSON TO USE AS SANDBAGS.
7. STRING OR CORD TO TIE CANOPIES AND SANDBAGS.
8. KNIFE.
9. SEVERAL BOARDS ABOUT 3 FEET LONG.
10. MEASURING TAPE AND/OR RULER.
11. WORK GLOVES FOR EACH WORKER.

HOW TO MAKE AN EARTH ROLL

1. SELECT A PIECE OF CLOTH OR PLASTIC AT LEAST AS STRONG AS A NEW BED SHEET, 2 FEET WIDER THAN THE SIDE OF THE OPENING TO BE PROTECTED, AND 5 FT. IN LENGTH.
2. PLACE 2 FT. OF THE LENGTH OF THE CLOTH ON THE GROUND, AS ILLUSTRATED.
3. WHILE USING BOTH HANDS TO HOLD UP 3 FT. OF THE LENGTH OF THE CLOTH AND WHILE PRESSING AGAINST THE CLOTH WITH YOUR BODY, HAVE ANOTHER PERSON SHOVEL EARTH ONTO AND AGAINST THE CLOTH.
4. WHILE STILL PULLING ON THE CLOTH, PLACE THE UPPER PART OVER THE EARTH THAT IS ON THE LOWER PART OF THE CLOTH.
5. COVER THE UPPER EDGE OF THE CLOTH, FORMING AN EARTH-FILLED "HOOK" IN THIS EDGE.

GENERAL INFORMATION

THIS SHELTER IS DESIGNED FOR AREAS WHERE THERE IS A SHORTAGE OF SMALL TREES AND/OR BUILDING MATERIALS. THE DEPTH TO GROUND WATER AND ROCK MUST ALSO BE BELOW THE BOTTOM OF THE TRENCH. IN ADDITION, THE EARTH MUST BE SUFFICIENTLY FIRM AND STABLE SO THAT THE TRENCH WALLS WILL NOT COLLAPSE. THE SHELTER (3-PERSON CAPACITY) CAN BE CONSTRUCTED BY 3 PEOPLE WORKING AN APPROXIMATE TOTAL OF 18 HOURS EACH. READ AND STUDY ALL INSTRUCTIONS BEFORE BEGINNING TO BUILD.

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Work Unit 1637E

ABSTRACT

Seventeen families attempted to build seven types of earth-covered expedient fallout shelters while guided only by one-page shelter-building instructions prepared by DCPA. Within 48 hours of starting, all but one family succeeded in building a shelter affording good fallout protection. Families spent an average of 88 minutes trying to interpret their one page of instructions. The abbreviated DCPA instructions for building an expedient shelter-ventilating pump - essential for the multiday occupancy of belowground shelters, except in cold weather - were followed successfully by only four out of nine families. This report makes numerous recommendations for improving all the instructions.

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